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(*Recognosce notum, ignotum inspice*)

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BRITISH SPECIES OF *HYSTERIUM*, *GLONIOPSIS*, *DICHAENA* AND *MYTILIDION*

By G. R. BISBY

(With Plate V and 1 Text-figure)

Little critical study has been given to the Hysteriales of Britain. A list of the species recorded, with references, is given by Bisby and Mason (1940).

European workers, up to a century ago, tried to differentiate species on the appearance of the hysterothecia and by their hosts. Later it became evident that spore-characters provide the main criteria for separating species and even genera. Mycologists then found themselves with a number of early descriptions without microscopic details and often unsupported by authentic specimens. They tried to fit their collections to existing names with little regard for any 'type specimens' extant. Every now and then a 'new species' was proposed for some new collection. Thus the taxonomy has become increasingly confused, and little is known either of the variation of the European species, or of their development in culture.

HYSTERIUM [Tode] Fr. emend. Sacc.

Two species of *Hysterium* have been recorded in Britain.

(I) *H. pulicare* Pers. ex Fr. occurs on bark and wood of broad-leaved trees, especially *Betula*. The ascospores are 18–35 × 6–10 μ. The specimens here described are about average for the species. They were on rough, black areas on bark of living *Betula*, Surrey, 9 Jan. 1938.

Hysterothecia scattered or gregarious, inconspicuous, superficial or nearly so, 0·4–1 mm. long, 0·3–0·4 mm. wide, about 0·3 mm. high, dull black, marked with an indistinct line or two each side of and parallel with the central cleft; the cleft gradually widens to expose the hymenium, which is coloured dark brown by the tips of the paraphyses; asci clavate, 8-spored, 1–3-seriate, about 100 μ long, spore-bearing part 50–80 × 15–20 μ; ascospores 21–26 × 6–8 μ, 3-septate, the two central cells olive-brown and larger than the end cells (e.g. a spore 26 μ long has central cells each about 8 μ and end cells each about 5 μ long); both end cells paler in about 80 per cent of the spores, only one end cell paler in about 10 per cent, and all four cells brown in 10 per cent.

Ascospores were discharged upon agar, and monosporous and polysporous cultures were readily obtained and transferred to various media. Quaker-oat agar was as good as any medium used.

Practically every discharged ascospore promptly germinated, first from both end cells, then usually also from one or both central cells. The mycelium grew slowly (colonies on agar 8–10 mm. in diameter after five weeks at room temperature), remained white for about a fortnight, then gradually darkened to olivaceous.

Pycnidia began to appear in about six weeks, and others continued to appear for several weeks thereafter. Beads of exuded spores were first whitish, then amber-coloured. The pycnidia were oval, 120–150 × 100–120 μ, with an ostiole about 45 × 15 μ; wall membranous, mycelioid-pseudoparenchymatous; conidiophores slender; conidia 3–5 × 1·5 μ, hyaline, eguttulate or sometimes biguttulate.

No hysterothecia developed in cultures kept for eleven months.

Lohman (1933*a*) obtained the same pycnidial stage in cultures of *H. pulicare*, described and figured it, and saw germinating conidia. It can be referred to *Hysteropycnis* (see below).

(II) *Hysterium angustatum* (Alb. & Schw. ex Fr.) Chev. was considered by Fries (1828), Duby (1861) and others to be a variety of *H. pulicare*. British mycologists have always treated *H. angustatum* as a distinct species, as most modern mycologists do, but Hilitzer (1929) placed it as a form of *H. pulicare*.

The spores of *H. angustatum* are shorter than in most collections of *H. pulicare*, being 15–23 (25) × 5–7 μ, and all their cells are brown. *H. angustatum* seems to occur more commonly on bare wood, and *H. pulicare* on bark, of broad-leaved woody plants.

Specimens on a fallen, decorticated branch of *Fraxinus*, Dorset, 9 June 1938 differed from those of *H. pulicare* described above as follows: the hysterothecia were more flexuous and usually narrower, particularly at the ends; the spores were 15–19 × 5–7 μ, often somewhat curved, and their end cells were little or no paler than the central. I considered this to be *H. angustatum* with spores rather shorter than usual.

The ascospores germinated as did those of *H. pulicare* and produced similar cultures and pycnidia. The conidia were smaller, 2–3 × 0·5–1 μ. This pycnidial stage agrees with *Hysteropycnis occulta* Hilitzer (1929), which he described as associated with *Hysterium pulicare* (called *H. alneum*); but, since he did not distinguish *H. angustatum* as distinct, Hilitzer's pycnidia may have belonged to the latter.

So far, so good; the two species seemed distinct in both perfect and imperfect states until Dr C. G. C. Chesters forwarded me a collection on a decorticated branch of *Fagus*, Ludlow, 7 April 1938. The hysterothecia were similar to those described above for *H. pulicare*; pycnidia associated on the branch had conidia 3–5 × 1·5 μ, like those

of *H. pulicare*; but the ascospores were those of *H. angustatum*, i.e. 18–23 × 6–7·5 μ, with end cells little or no paler than the central cells. Cultures were made but no pycnidia were found. Lohman (1933*a*) also obtained no pycnidia or spores from his specimens intermediate between *H. pulicare* and *H. angustatum*.

But after examining many specimens, I still distinguish *H. angustatum* by its uniformly brown ascospores and their smaller size. I do not find that characters of hysterothecia or pycnidia are useful in differentiating the two.

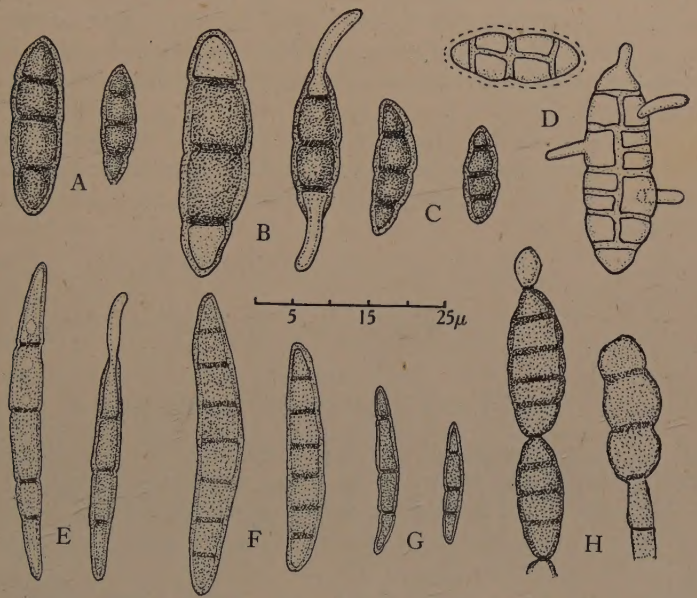

Fig. 1. The approximate range in size of ascospores is given. A, *Hysterium angustatum*. B, *H. pulicare*, one spore germinating; pycnidiospores at left. C, *H. acuminatum*. D, *Gloniopsis levantica* (=*G. curvata*?); the germinating spore has lost its gelatinous outer wall. E, *Mytilidion Karstenii*, one germinating. F, *M. gemmigenum*. G, *M. laeviusculum*. H, *Septonema* spores from culture of *Mytilidion Karstenii*. All × 1000.

(III) *Hysterium acuminatum* Fr. sensu Rehm. *Hysterium acuminatum* Fr. was described on *Fagus* with no mention of spores, and apparently without preserving specimens. Rehm (1887) applied the name to an alpine *Hysterium* on *Pinus* and *Larix*, and described ascospores 12–15 × 5–6 μ. I (1932) measured the spores of Rehm *Ascom.* 125 as 13–16 × 5–6 μ, and Phillips measured them as 14–18 × 5–6 μ (unpublished note in Kew Herbarium).

Hysterium acuminatum has not been recorded for Britain, but there are two specimens in Kew Herbarium, previously un-named, which

I consider to be this species. One is from Cooke's Herbarium, marked "No. 2. Hysterium on Pine Dolgelly June 1876." It was probably sent to Cooke by the Rev. W. A. Leighton. The hysterothecia on thick bark of *Pinus* are nearly superficial, elliptical, 0·4–8 mm. long, about 0·3 mm. wide and the same height, sessile, flat, dull black, groove becoming partially open; asci about 75 × 10μ, 8-spored, 1–2-seriate-overlapping; ascospores 14·5–18 × 4·5–5·5μ, narrowed and rounded at the ends, 3-septate, uniformly brown, each of the four cells about equal in length.

Another specimen is marked by Berkeley "Hysterium. Norths." It consists of a branch of ? *Larix*, with hysterothecia on the bark similar to those of the Dolgelly specimen but less weathered, and some reach a length of 1·7 mm. The asci and spores are the same in both specimens.

Few or none of the Hysteriales are known to occur on both Gymnosperms and Angiosperms. I consider that these three species of *Hysterium*, all of which have 4-celled ascospores, can be distinguished as follows:

On conifers; spores 12–18 × 5–6μ, all cells brown...*H. acuminatum.*
On hardwoods; „ 15–24 × 5–7μ, „ „ „ ...*H. angustatum.*
„ „ „ 18–35 × 6–10μ, end cells paler *H. pulicare.*

GLONIOPSIS de Notaris

One of the commonest of the British Hysteriales is a *Gloniopsis* to be found in almost any clump of old *Rubus*, and on branches of various other Dicotyledonous shrubs or trees, or rarely on old herbaceous stems (I have examined specimens on *Rumex* and *Teucrium*). This fungus has the following characters:

Hysterothecia 0·5–3(5) × 0·3–0·8 mm., 0·3–0·5 mm. high, superficial or erumpent, straight or somewhat curved, parallel or transverse, scattered, gregarious, or crowded; asci 75–120 × 15–20μ, usually 8-spored, irregularly biseriate; ascospores (15) 17–27(32) × 6–10(12)μ, hyaline or pale yellowish, elliptical, usually somewhat constricted at the centre and the upper part of the spore slightly larger, with 3 to 7 cross septa, central cells with 1 or 2 longitudinal septa and often with a cross septum dividing only one of the cells, septa about 1μ wide, outer wall 1–2μ thick, becoming gelatinous and swelling in water until it disappears leaving a very thin inner wall; paraphyses filiform, branched above to form a coloured epithecium beyond the young asci.

I have studied about fifty British collections of *Gloniopsis*. One might base two or three doubtful species on only five well-chosen collections, but the fifty collections seem to represent but one good species. The size and appearance of the hysterothecia depend upon

the host, the weather, etc. I have specimens in which superficial and half-immersed hysterothecia, with exactly similar spores, are adjacent.

The asci show only the variation expected between slight immaturity and the expansion preparatory to discharging spores. The ascospores vary in size and number of cells in different collections, or in the same collection; I have found spores from one fruit-body with a range of 17–31 × 7–11 μ, and only spores which were outside the asci and presumably mature were measured. (This hysterothecium happened to have a number of asci with only two or four spores.)

The variations in measurements of *Gloniopsis* recorded in the literature are due in part to three causes: (1) the spores remain hyaline, and immature spores may be measured in the asci and considered mature; (2) the gelatinous outer wall is sometimes included, sometimes omitted; (3) there is the large "personal factor" of the measurer, including that of knowing what the size is supposed to be.

Cultures from ascospores were made from eleven collections. All cultures were similar, with the expected minor differences in cultural characters. Two cultures from *Rubus* and one each from *Prunus* and *Ligustrum* produced a narrow orange-coloured zone at the margin of the colony on Quaker-oat agar; this zone was not observed in cultures from *Acer*, *Rosa*, *Lonicera*, *Rumex*, *Quercus* or *Salix*; but different lots of agar were used. Pycnidiospores were found in about half the cultures. I found no morphological characters of hysterothecia or spores that I could correlate with these minor differences in culture.

Ascospores discharged upon agar remain hyaline or faintly yellow, swell slightly, the constriction may be obliterated, and germ tubes soon appear from any or all cells.

The colonies grow slowly, are first white then dark with a pale woolly overgrowth. Pycnidia may appear after a month or two. The small pycnidia were so enmeshed in the mat of mycelium that I did not obtain a clear idea of their morphology, but apparently they are similar to those produced by *Hysterium pulicare*. The pycnidiospores (or spermatia?) are 2–4 × 1·5–2 μ, hyaline, borne on slender sporophores 10–15 μ long.

Hilitzer (1929) found pycnidia with similar spores associated with *Gloniopsis biformis* (see below), and named this stage *Hysteropycnis admixta*. Lohman (1933*a*) obtained similar pycnidiospores in cultures of *Gloniopsis Gerardiana* Sacc.

Some analysis is required to ascertain the name for this *Gloniopsis*, now usually called *G. curvata* in Britain.

Fries (1828) cited a Mougeot specimen on *Rosa canina* for *Hysterium elongatum* Wahlenb. ex Fr. var. *curvatum* Fr. Duby (1830) raised the variety to specific rank and cited a Mougeot specimen on *Prunus spinosus*, Vosges. In his Mémoire, Duby (1861) reported that the

spores were hyaline and muriform, mentioned four localities including "Anglia (cl. Bloxam!)", and made *Hysterium naviculare* Wallr. (from Thuringia) a synonym.

Meanwhile Berkeley had recorded *Hysterium curvatum* from Britain in 1851 and 1860 without notes on spores, but a specimen from his Herbarium "May 15, 1841. W. A. L[eighton]" has accurate sketches by Berkeley of three spores, "coat gelatinous", and two asci. A mount shows the spores to be up to 25μ long and typical of our common *Gloniopsis*.

Cooke (*Handbook*, 1871) said the spores of *Hysterium curvatum* were 12·5–15 × 3·5μ. This was apparently the first report of measurements of ascospores of *H. curvatum*. Saccardo (*Sylloge*, II, 1883) transferred the species to *Gloniopsis* and gave the spores as "12–15 × 3·5μ", evidently taken from Cooke. Thus the great weight of the *Sylloge* has supported Cooke's mismeasurements for sixty years. An examination of the specimens in Cooke's herbarium shows that the sizes he gave should be multiplied by about two.

Rehm (1886) renamed Duby's specimens and gave spore-sizes of many of them. *Hysterium naviculare* Wallr. was found to have spores 15–18 × 6–7μ, hyaline, muriform, with 3–5 cross septa, elliptical, slightly constricted, lower part of the spore somewhat smaller. Bloxam's specimen was described in similar words, and the spores were given as 15–17 × 6–7μ. Both were considered to be *Gloniopsis curvata*, although neither Duby nor Rehm seem to have examined Mougeot's "type" on *Rosa*.

Rehm found a specimen on *Rubus* in Duby's herbarium from Île du Levant (south coast of France) with spores 21–24 × 9μ, and named it *Gloniopsis levantica*.

Massee (1895) included *Gloniopsis curvata*, gave the spores as 15–19 × 6–8μ, published inaccurate figures, and stated "specimen named by Fries examined". (I find no such Friesian specimen in Kew Herbarium.)

Paoli (1905) examined the type specimen of *Gloniopsis curvata* from Fries's Herbarium and reported that the spores were 14–15 × 6–7μ. Six other specimens studied by Paoli, three from Italy and three from Britain, were found to have spores 18–25 × 7–9μ, and were referred to *G. levantica* Rehm.

It would appear, therefore, that the name *Gloniopsis curvata* should refer to a small-spored species on the Continent, and that the name *G. levantica* refers to a larger-spored species in the Mediterranean region and in Britain. Material is not available to solve this problem, for Kew Herbarium has no specimen marked *G. levantica*, has about thirty specimens from Britain marked *G. curvata*, but which agree with the description of *G. levantica*, and has no specimen from the Continent marked *G. curvata*.

We must now introduce the name *Gloniopsis biformis*, reported once from Britain for a specimen now apparently lost.

Hysterium biforme Fr. was distributed as *Scler. Suec.* No. 329. It was named "biforme" because some of the hysterothecia are elongate and others short. The specimens of this number at Kew and Paris are *H. angustatum* or *H. pulicare*; Duby found muriform dark spores.

Saccardo found specimens on *Quercus* that were "biforme", assumed that they represented Fries's species, and described them carefully as *Gloniopsis biformis* "(Fr.) Sacc." The following tabulation gives various reports on ascospore characters from Saccardo onward:

	G. biformis			*G. curvata*	
Author	Cross septa	Size μ	Conidia μ	Cross septa	Size μ
Saccardo (1883)	3	14×7–8	4×1	5–7	12–15×3·5
Saccardo & Roum. (1883)*	3	20–22×8–10	—	—	—
Rehm (1887)	3	15×5–6	—	4–6	15–18×6–7
Schroeter (1893)	4–5	18–24×9–12	—	2–3	15–18×6–7
Paoli (1905)	3	14×7–8	—	4–5	14–15×6–7
Hilitzer (1929)	3–4	15–20×7–8	3–5×1·5	4–5	16–23×6–9

* Saccardo & Roumeguère at least admitted the possibility that the species might be variable.

Rehm and others have used *Gloniopsis* as a subgenus of *Hysterographium*. Hilitzer, recognizing that the type of *Hysterium biforme* did not belong to the same species as *Gloniopsis biformis* Sacc., renamed the latter *Hysterographium Dubyi* Hilitz.; he also described var. *acuminatum* with ascospores 15–16×6–7μ, and associated pycnidiospores 3–4×1μ.

Part of the specimen which Saccardo described as *Gloniopsis biformis* is at Kew. It has small, mostly immature ascospores 14–16×6–7μ with 3 cross septa, one cell (usually) with a longitudinal septum. I measured the pycnidiospores as 2–4×1μ. There is also a specimen from Wallroth, on *Crataegus*, Thüringia, with spores 13–18×5–6μ, but apparently also immature. The specimen at Kew of Sydow, Mycotheca Marchica 952, marked *Hysterium biforme* Fr., is *Hysterographium elongatum* (Wahlenb. ex Fr.) Corda. There is no other specimen in the *Gloniopsis biformis* folder at Kew.

Thus there are two specimens from the Continent in Kew Herbarium, marked *Gloniopsis biformis*, which may represent the small-spored species that *G. curvata* is supposed to be. Or they may have small spores because they are immature or "off-type". It should be noted that Saccardo's specimen of *G. biformis* has conidia such as one obtains in cultures from the ordinary British *Gloniopsis*. Hilitzer's studies seem to me to indicate that there is one *Gloniopsis* in Czecho-Slovakia resembling the British species, though he referred the specimens to two species and one variety.

There remains the specimen sent to Duby by Bloxam, which Rehm said had spores 15–17 × 6–7μ. In specimens at Kew from Bloxam and others it is easy to find a hysterothecium with spores of that size, but immature; in British specimens from Bloxam and from others the length of the mature spores reaches 22 or often 25μ or more. To avoid ambiguity we may designate this common British species *Gloniopsis levantica*.

There are records of four more species of *Gloniopsis* in Britain, each based on a single collection.

1. *Gloniopsis Vaccinii* (Carm. ex Berk.) Boughey in *Trans. Brit. Mycol. Soc.* XXII, 239, 1939. An examination of the type shows that this is *G. levantica*, as Boughey suspected. *G. Vaccinii*, however, does not provide a valid name for the species, because *Hysterium Vaccinii* Carm. ex Berk. is a later homonym of *H. Vaccinii* Schweinitz.

2. *Gloniopsis Muelleri* (Duby) Sacc. was recorded from the Clare Island Survey. Dr Ramsbottom of the Natural History Museum kindly loaned the specimen to me, and I found it to be typical *G. levantica*. A specimen in Kew Herbarium on *Cistus*, Kew, is labelled *G. Muelleri*. It is immature, but probably *G. levantica* also. *Hysterium Muelleri* Duby was described from the Île du Levant (type locality of *Gloniopsis levantica*). Part of the type specimen is at Kew. I have examined it and consider that it may be the same as *G. levantica*. Rehm (1886, 148) gives a description which suggests *G. levantica*. However, *G. Muelleri* is a more or less forgotten name which, in my opinion, might better remain forgotten.

3. *Gloniopsis decipiens* de Not. was recorded (*Trans. Brit. Myc. Soc.* III, 282) from Wales on palings, probably of *Quercus*. This specimen is not available at the moment and Miss Smith's description was apparently taken from Rehm.

The genus *Gloniopsis* was based on *G. decipiens*. Rehm (1887) records only the type and a collection on *Quercus* "in Franken". It was thought to differ from *G. levantica* in having rather larger spores (21–30 × 9–12μ) without constriction.

I have seen two or three British collections which might be referred to *Gloniopsis decipiens*; one "on a gate", coll. Dr Watson, comm. F. Rilstone, has spores up to 32μ long, many-celled, with little or no constriction. I consider it better, however, to consider that *G. decipiens* represents *G. levantica* with well-developed spores, while Saccardo's *G. biformis* may be *G. levantica* with poorly developed spores. Certainly the *Gloniopsis* one usually collects on *Quercus* has the intermediate spores of *G. levantica*.

Kew Herbarium has no authentic material of *Gloniopsis decipiens*; *Rabenhorst Herb. Mycol.* Ed. II, No. 573 so labelled is a *Hysterographium*, and *Roum. Fungi Sel. Exs.* No. 5451 "f. *Pini*" on *Pinus* is apparently without hysterothecia. I found only the same two Exsiccati at the Bot. Mus., Berlin, and I did not find a good specimen at Paris.

4. *Gloniopsis Watsonii* Rilstone in *J. Bot.* 1940, p. 192 is described with spores up to 51 × 21 μ. I have not studied it, but it is certainly different from all other British collections of *Gloniopsis*.

DICHAENA Fr.

Dichaena faginea (Fr.) Fr. and *D. quercina* (Fr.) Fr. are amongst the most common and uninteresting fungi in Britain. I have looked at many specimens but have never found an ascus.

Dichaena was first considered a Lichen. Roper (1874) (taken from *Monthly Microscopical Journal* which I have not seen) reported asci with spores "oval, the largest about 0·001 inch in length; they are filled with granular matter, of a pale brownish tinge variegated by a mixture of bluish-green". Roper also reported algal cells associated, but Cooke added a note saying he was changing his mind (he had previously thought *Dichaena* a Lichen) and suggested that the algal cells were accidentally present.

About 1876 Cooke issued *Fungi Brit. Exs.*, Ed. II, No. 464 with a printed sketch of a clavate ascus with eight spores, a paraphysis, and a one-celled spore with "granules". This is the earliest figure of ascospores I have found; and I suggest that neither Roper nor Cooke ever saw an ascus or ascospore of *Dichaena*.

In 1881, Saccardo thought he saw diffluent asci with four-celled ascospores in *Dichaena quercina*, and in 1883 he figured an ascus and spores. The size of the ascus was not given, but the figure shows an ascus nearly cylindrical. In 1887 Rehm reported that he had seen pyriform asci, 45–50 × 25–27 μ, in one of his specimens, but since he found no developed ascospores he quoted Saccardo's description of spores. Rehm's figures of ascospores do not agree with the description, but resemble Cooke's hypothetical ascospores.

Massee (1895) then redrew Rehm's figures, but carefully placed three septa in the ascospores, except those in the ascus which he accidentally drew as muriform. Meanwhile Ellis and Everhart (1892) thought they found clavate asci 80–90 × 20 μ with septate ascospores 20–24 × 7–8 μ.

Paoli (1905) decided that Saccardo's supposed ascospores were pycnidiospores, for which he proposed the new genus *Dichaenopsis*; he found *Melogramma* on Ellis and Everhart's specimen; he found an Italian specimen of *Dichaena quercina* with compressed asci 80 × 26 × 15 μ and ascospores 18–20 × 13 μ, one-celled, hyaline then brown. He also figured and described *Psilospora Quercus* with hyaline one-celled pycnidiospores (similar to those of *P. faginea*) but other workers consider that *P. Quercus*, the supposed pycnidial state of *Dichaena quercina*, has pycnidiospores becoming septate. Diedecke proposed the genus *Psilosporina*, which is presumably a synonym of *Dichaenopsis*.

Thus it must be concluded that the pycnidial state of *Dichaena quercina* is nearly as uncertain as the ascigerous. I can add no information, for my experience is the same as Grove's (1937): "common... but always barren".

In 1914 Arnaud figured *Dichaena quercina*, without discussion. His illustration of a section of a fruit-body shows structures that look like asci, but no spores are shown within. Arnaud figures "ascospores" which look like pycnidiospores of *Psilospora Quercus* sensu Paoli.

In 1918 von Höhnel reported that he did not find ascospores, but he accepted Paoli's description of them.

Apparently no one has yet thought he had seen an ascus in *Dichaena faginea*, though they are reported for its var. *Capreae* Rehm. The third species of *Dichaena* recorded in Britain, *D. strobilina* (Fr.) Fr., is especially doubtful, though Cooke reported ascospores in 1871.

The so-called pycnidial state of *Dichaena faginea*, *Psilospora faginea* Rabenh., is sometimes found. E. W. Mason collected good specimens on an exposed root of *Fagus*, at Ranmore Common, Surrey, 12 Feb. 1939. The pycnidiospores were 12–28 × 8–15μ, hyaline to pale yellow, granular, borne on slender sporophores. I made several cultures, then placed the *Psilospora* in a damp chamber, but no asci developed. I watched the cultures for several months, but found only brownish mycelium and minute microconidia or spermatia.

Dichaena should be removed from the Ascomycetes until someone is sure he has seen an ascus and ascospores. This genus, though very common in Europe and North America, has been reported to have ascospores that belong to Hyalosporae, Phaeosporae, Hyalophragmiae, and possibly to Phaeophragmiae; but most mycologists have never been able to find its ascospores at all. I would place *Dichaena* in the Sphaeropsidales, with *Psilospora* as a synonym, although there is doubt even as to its place in the Fungi Imperfecti. I hope someone with more patience may ascertain the facts about *Dichaena*, *Psilospora*, and *Dichaenopsis*.

MYTILIDION Duby

Mytilidion and *Lophium* differ from other lignicolous and corticolous Hysteriales in Britain in their erect, conchiform or mussel-shaped, thinner-walled hysterothecia. Three species of *Mytilidion* have been recorded for Britain, two of them apparently based on one collection.

Mytilidion decipiens (Karst.) Sacc. was reported by Bucknall (as *Lophium*) on pine wood near Bristol, coll. Mar. 1885. Bucknall's herbarium was not saved, but part of this collection was sent to Cooke and is now in Kew Herbarium. It is not *M. decipiens* but *M. laeviusculum*.

Mytilidion laeviusculum (Karst.) Sacc. is recorded by Massee (1895) "on worked pinewood". No British specimen is in the *M. laeviusculum* folder at Kew, so I presume Massee may have examined Bucknall's

specimen, although he did not mark it or remove it from the *M. decipiens* folder.

This specimen bears a few small, erect hysterothecia with asci about 80–90 × 6μ, ascospores 16–22 × 2·5–3μ, 1–3-septate, brown.

No imperfect stage is known for *M. laeviusculum*, and Lohman (1933*b*) obtained none in cultures from the only recorded American collection. Lohman (1939) restudied Karsten's type specimen. Part of the same collection was distributed as *Fungi Fenn.* No. 771. I found that this number at Berlin had ascospores, but not its counterpart at Kew. *M. laeviusculum* seems to be a rare species in Europe; Kew has only the Finnish specimen and Bucknall's, and Berlin only a couple of collections from Karsten.

Mytilidion gemmigenum Fuckel is represented at Kew by several specimens, including the following from Britain: (1) one or two collections from Bloxam on "Scotch fir", in which I found no ascospore, but the erect hysterothecia and a sketch of spores beside one specimen indicate that it is *M. gemmigenum*; (2) a collection on bark of *Larix*, Worcs., ex Herb. J. W. Ellis, in which the asci are immature; (3) several parts of one or two collections by Plowright, King's Lynn, apparently on *Larix*. These were distributed by Cooke as *Fungi Brit. Exs.* No. 580 and ibid. Edit. 2, No. 200, both under the name *Lophium mytilinum*. In 1876, Cooke decided to name No. 200 *L. fusisporum* Cooke, which Saccardo transferred to *Mytilidion*. Massee (1895) made *M. fusisporum* a synonym of *M. gemmigenum*.

These Plowright specimens—the only British collections I have seen with asci and spores—do not provide many data, but I found the asci to be about 100 × 10μ, with 8 or sometimes fewer spores; ascospores 30–40 × 5–6μ, usually 7-septate. *Mytilidion gemmigenum* seems to be the correct name, but I have been unable to study an authentic specimen, since I found no hysterothecium on Fuckel's *Fungi Rhenani*, No. 2433 at Kew. Rehm's *Ascomyceten*, No. 129 on *Pinus* has spores similar to those mentioned above, but up to 8μ wide and to 9-septate.

A third species of *Mytilidion* was collected by Mrs Una C. Mason near Ludlow on a fallen branch of *Pinus*, 25 Sept. 1937. The hysterothecia are on bare wood, erect, 0·04–0·08 mm. long; asci 125–150 × 8μ, 8-spored; ascospores 28–42 × 3·5–4μ, brown, 3–4(5)-septate, slightly or not constricted at the septa.

This is evidently *Mytilidion Karstenii* Sacc., as redescribed by Lohman (1939) from the specimen he considered the type; it is a new record for Britain. The only European specimen marked *M. Karstenii* in Kew Herbarium is one correctly determined by Massee, with ascospores 30–40 × 3·5–5μ, 3–4-septate. No locality is given, but it may have been a British collection.

Ascospores from the Ludlow specimen germinated always from one

and sometimes from both of the terminal cells, and produced a woolly blackish mycelium and the abundant conidia of a *Septonema*. Lohman observed the same *Septonema* associated with the type specimen. No specific name has been found for this stage. Lohman (1933*b*) obtained *S. toruloideum* Cooke & Ellis from ascospores of *Mytilidion scolecosporum* Lohman.

A word must be said about *Mytilidion aggregatum* (DC. ex Fr.) Duby, the type species of the genus, and *M. rhenanum* Fuckel. Duby (1861) described and figured the genus with ascospores first simple, hyaline, elliptic, then with three cross-septa, the two middle cells pale brown. He cited for *M. aggregatum* a Chaillet specimen, Fries's Scler. Suec. 351 issued as *Lophium aggregatum* (DC.) Fr., *Hysterium aggregatum* DC., and a Lamy specimen from which he apparently drew his figures. Kew has part of the Chaillet specimen, collected 1816, but I found no spore; it has also three parts of Scler. Suec. 351, but I found no spores on those either. As Kew has no other specimen of *Mytilidion aggregatum*, I can give no new information about the species.

Fuckel issued *Fungi Rhenani*, No. 761 as *Mytilidion aggregatum*, and gave (*Symb. Myc.* p. 93, 1869) the spores as 38×3–6μ, 3–5-septate, yellow when mature. In Nachtrag 1, 1871, he decided that his No. 761 did not agree with Duby's figures, so he described it as *M. rhenanum* Fuckel; and now said the spores were 36–38×4–6μ, 3-septate, brown.

The Kew specimen of Fuckel No. 761 has ascospores 32–$44 \times 3{\cdot}5$–$4{\cdot}5\mu$, brown, 3–5-septate, and is the same as *Mytilidion Karstenii*. Rehm (1887) and others give the spores of *M. rhenanum* as 24–27×5–6μ. Hilitzer (1929) makes *M. rhenanum* a synonym of *M. aggregatum*, and gives the ascospores as 20–$27 \times 7\mu$. Possibly Fuckel distributed two species in his 761. In view of this uncertainty, I use the name *M. Karstenii* for the British specimen.

FARLOWIELLA Sacc.

E. W. Mason (1941) has just reported on this genus and its one species, with the conidial stage *Monotospora megalospora* Berk. & Br.

Discussion and Summary

With *Dichaena* excluded, the lignicolous and corticolous Hysteriales constitute a fairly homogeneous group easily recognized by the elongate fruit bodies, or hysterothecia. But the numerous cultures reported by Lohman (1933 and subsequently), and the few reported here, show that there is no corresponding similarity in their conidial stages, which are sometimes pycnidial, sometimes Hyphomycetous. Nor do genera with erect hysterothecia, such as *Mytilidion*, have conidial stages distinct from those of genera with non-erect hystero-

thecia; a *Septonema* stage was found by Lohman for *Hysterium insidens* as well as for certain species of *Mytilidion*; other species of *Mytilidion* and *Hysterium* have pycnidial stages.

Three species of *Hysterium* are known in Britain. *H. angustatum* is fairly common, *H. pulicare* rather less common, and *H. acuminatum* apparently rare. These three species are somewhat similar in morphology, but are almost always easily distinguishable.

Gloniopsis Watsonii is known only from the type collection, and I am uncertain about it. The common British *Gloniopsis* on various woody Dicotyledonous branches and stems seems to me to constitute one species, as neither morphological nor cultural characters have provided criteria for distinguishing two or more species. I have accepted for this the name *G. levantica*. It is possible that the name *G. curvata* refers to a smaller-spored species on the Continent, and even in Britain also; until that is demonstrated more clearly, some may prefer to follow tradition and call the British species *G. curvata*. The pycnidial stage appears to be a *Hysteropycnis*.

Mytilidion and *Farlowiella* have rarely been collected in Britain. *Mytilidion Karstenii* produces a *Septonema* stage. *Mytilidion laeviusculum* and *M. gemmigenum* have been reported previously from Britain.

Dichaena has long been classified as an Ascomycete, but should be placed in the Fungi Imperfecti until ascospores are really known.

Precise formal descriptions of species of Hysteriales in Britain, and full synonymy, can scarcely be given until other European specimens are studied more carefully.

Acknowledgements. About twenty years ago Sir Edwin Butler and E. W. Mason suggested (rightly) that the Hysteriales needed some study. The authorities of the Royal Botanic Gardens, Kew, have always allowed me to feel at home in the Herbarium, and Miss Wakefield has helped me in various ways. Dr C. G. C. Chesters and Mr F. Rilstone have kindly placed numerous specimens at my disposal.

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EXPLANATION OF PLATE V

Fig. 1. *Gloniopsis levantica* (=*G. curvata* of British mycologists) on cortex of *Rosa*. ×25.
Fig. 2. *Hysterium angustatum* on wood of *Fraxinus*, ×25. The genus cannot be determined by appearance of hysterothecia.
Fig. 3. *Mytilidion Karstenii* on wood of *Pinus*, ×25. The hysterothecia are erect, and narrowed below.
Cultures were made from the three collections photographed.

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Fig. 1

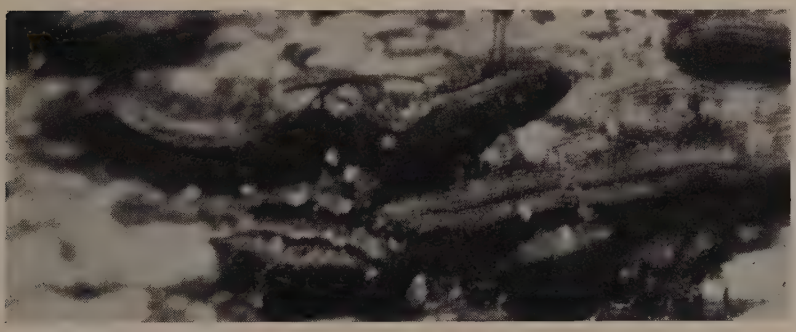

Fig. 2

Fig. 3

A METHOD FOR CHARACTERIZING SMUT FUNGI EXEMPLIFIED BY SOME BRITISH SPECIES

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In the course of studies on the Ustilaginales the need was felt for a shorthand method of recording the principal characters of each species examined. Suggested by the numerical formulae used for bacteria and the formulae proposed by Beeli (1920) and by Stevens (1927–8), for species of *Meliola*, the method developed consists in assigning to each species a formula of twelve numerals. The first four numerals (A) represent macroscopic characters (or characters which require only supplementary microscopic examination), the second four (B) microscopic characters, and the third four (C) measurements; the numeral for each character being selected by reference to the following table:

A. Macroscopic characters

1st numeral: The position of the sorus

Sori:

A, in the ovaries (or replacing the flower parts within the perianth)	1
B, in the seeds of fruits[1]*	2
C, in the anthers	3
D, in the inflorescence (including peduncle and pedicel) ...	4
E, transforming the floral axis into a long curved leafless structure[2]	5
F, in the leaves and/or stems	6
G, in the flowers (or inflorescence), leaves, and stems ...	7
H, in roots, tubers, or other underground parts	8

2nd numeral: The covering of the sorus

Sorus:

A, not delimited by an evident false membrane of fungal tissue (protective covering, when present, of host tissue)	0
B, delimited by an evident false membrane of fungal tissue	1

* See notes at the end of this table.

3rd numeral: The internal structure of the sorus

Sorus:

A, not traversed by a columella or by threads of host tissue 0

B, traversed by:

(A) a central columella[3] that is

a, simple 1

b, forked or branched 2

(B) several to numerous strands of host tissue arising from the base of the sorus[4] 3

(C) very numerous fine elater-like threads of host tissue[5] 4

4th numeral: The macroscopic appearance of the spore mass

Sorus:

A, opening on the host to expose:

(A) a dusty spore mass that is:

a, black (olivaceous black, or purplish black) ... 1

b, brown (olivaceous brown, or reddish brown) ... 2

c, purple (pinkish, or reddish purple) 3

d, pale (light brown, fawn, or yellow) 4

(B) an agglutinated spore mass 5

B, not opening on the host, permanently embedded in the host tissue or enclosed in a seed or fruit; the spore mass being:

(A) coalescent or agglutinated 6

(B) not coalescent or agglutinated; dusty 7

B. Microscopic characters

5th numeral: The microscopic appearance of the spore mass

In mature sori, the spore mass:

A, homogeneous, consisting of mature spores or mature spore-balls only 1

B, heterogeneous, consisting of mature spores or mature spore-balls intermixed with:

(A) sterile cells which are not an integral part of a spore-ball (frequently derived from the false membrane), or sterile or permanently immature spores[6] ... 2

(B) sterile mycelial threads[7] 3

6th numeral: Spores single, in pairs, or in balls

Spores:

A, not in balls:

(A) single 1

(B) in pairs[8] 2

B, united into balls composed of:

(A) fertile spores only, the spores:

a, not bound together by thickenings or ridges of outer wall[9] 3

b, bound together by thickenings or ridges of outer wall[10] 4

(B) fertile spores and sterile cells, each ball having:

a, a sterile cortex enclosing:

(*a*) one or more fertile spores only[11] 5

(*b*) fertile spores and sterile cells or hyphae[12] ... 6

b, a fertile surface composed of:

(*a*) one to several layers of spores[13] enclosing sterile cells or tissue 7

(*b*) a single layer of spores enclosing a network of septate filaments[14] 8

c, the spores and sterile cells intermixed[15] 9

7th numeral: Spore ornamentation[16]

Each spore:

A, without an elongate hyaline appendage: its exospore:

(A) smooth 0

(B) apparently smooth but obscurely ornamented when highly magnified, or granular 1

(C) punctate 2

(D) verruculose to verrucose;[17] tuberculate 3

(E) echinulate to spiny[18] 4

(F) papillate 5

(G) scaly 6

(H) striate 7

(I) reticulate 8

B, with an elongate hyaline appendage[19] 9

8th numeral: Spore coloration

Mature spores:

A, homogeneous, i.e. all the spores similar; individual spores:

(A) evenly coloured:

a, hyaline to tinted 1

b, pigmented 2

c, densely pigmented to opaque 3

(B) more strongly pigmented on one side than the other [20] 4

B, heterogeneous: outer spores of a spore-ball more strongly pigmented than the inner spores 5

C. Measurements [21]

	9th numeral	*10th numeral*	*11th numeral*	*12th numeral*	
	Mean max. spore diam. in μ	Mean max. spore-ball diam. in μ	Mean sorus length in cm.	Mean max. diam. of sterile cells, sterile spores, cells of false membrane, sterile cortical cells of spore ball, or conidia of an *Entyloma* in μ	
1	5 or less	20 or less	0·5 or less	5 or less	1
2	7·5	30	1·5	7·5	2
3	10	40	2·0	10	3
4	12·5	60	3·0	12·5	4
5	15	80	4·0	15	5
6	17·5	100	6·0	17·5	6
7	20	125	8·0	20	7
8	25	150	10·0 or more	25	8
9	30 or more	200 or more	indefinite [22]	30 or more	9

Notes

(1) As when the spores remain enclosed within the fruit or seed after detachment from the plant, e.g. *Tilletia Caries* on wheat and *Ustilago seminis-convolvuli* on *Convolvulus*.

(2) As in *Ustilago scitaminea* on sugar-cane.

(3) 'Columella' is interpreted broadly. Besides the typical columella found in species of *Sphacelotheca*, a culm completely surrounded by a sorus as that of *Ustilago hypodytes* is considered to be a columella.

(4) As in some tropical species of *Sorosporium*, e.g. *S. Tembuti*.

(5) As in *Farysia*.

(6) Sterile cells derived from the false membrane are often exhibited by *Sphacelotheca* and *Sorosporium*; sterile or immature spores by *Tilletia*.

(7) As in *Farysia*.

(8) As in *Schizonella*, *Schroeteria*, and *Mycosyrinx*.

(9) As in *Sorosporium*.

(10) As in *Tolyposporium*.

(11) As in *Urocystis*.

(12) As in *Testicularia*.
(13) As in *Doassansiopsis*.
(14) As in *Tracya*.
(15) As in some species of *Burrillia*.
(16) An asterisk is used to denote ornamentation confined to one side of a spore. Thus when a spore from a spore ball is echinulate only on its free surface it is recorded as 4*.
(17) Verrucose, warty; verruculose, minutely warty.
(18) Echinulate, minutely spiny; spiny, strongly echinulate.
(19) As in *Neovossia*.
(20) As in *Ustilago Tritici* and *U. Avenae*.
(21) At first the maximum length was recorded but the mean was found to give slightly less variable results. The mean is that of ten measurements, taken at random but with the proviso that the largest and smallest individuals observed are measured. The calculated mean is referred to the nearest class in the table.
(22) 'Indefinite' includes irregular sori on leaves and stems.

Examples

The use of the method may be exemplified by the formulae for the Loose and Covered Smuts of Sorghum. The first, *Sphacelotheca cruenta* (Kühn) Potter is represented by:

1112.2102.2014,

which may be expanded as follows:

Sori in the ovaries, [conspicuous], average length 0·5 cm. or less [but occasionally larger], limited by an evident [somewhat evanescent, cream-coloured] false membrane [which disintegrates at maturity to expose] a [dark] brown, dusty spore mass surrounding a [long, curved, well-developed] simple columella [of host tissue]; spores intermixed with [groups of globose to subglobose, hyaline] sterile cells, [9–16] (av. 12·5) μ in length; spores single, [globose to subglobose], smooth, evenly pigmented [light reddish brown, 6–10] (av. 7·5) μ in length.

(The square bracket insertions give supplementary information not indicated by the formula.)

The formula for the second, *Sphacelotheca Sorghi* (Link) Clint. is:

1112.½102.1012,

and can be expanded on similar lines. The fifth term indicates that the character in question is usually 1 but sometimes 2, i.e. 'spores not usually but sometimes intermixed with [chains of subglobose, hyaline] sterile cells [derived from the false membrane, 4–8] (av. 7·5) μ in length'.

Further examples are given in the Appendix where the formulae for 45 British smuts, based on an examination of specimens, are set out.

Applications

No claim is made that a species can be completely described by a formula. It is only claimed that the construction of a formula assists the adequate description of any species. Although the characters set out in the above table vary in importance for generic or specific characterization each merits consideration for specific descriptions; and the mere making of the observations necessary to prepare a formula ensures a systematic examination of the specimens. Only too frequently is it impossible to complete the first two sections of the formula from the published description of a smut.

There has been a greater tendency to raise physiologic races to specific rank in the Ustilaginales than in most other groups of fungi and formulae help to emphasize morphologically similar types that occur on different host plants.

Collections of formulae may be arranged in various ways as identification keys. They may be arranged in order (as in the Appendix) when to name a specimen its formula is determined and then matched with the list. By this method use of the host plant is sometimes necessary (particularly in the genus *Entyloma*) to separate species with identical formulae. Recourse to the host plant compares favourably with their use for the final separation of species in the usual type of dichotomous key. A second method is to group the formulae under the host genera which is in some ways more useful than the first for the name of the host plant is usually known. Duplication, however, results when one species has to be entered under several genera and the key breaks down whenever an already described smut is first recorded on a new host genus. A third alternative is to transfer the formulae to perforated cards of the type used by Clarke (1938) when the multiple-entry keys so obtained can be approached via any character. A 5×8 Paramount Sorting Card allows geographical distribution or other information to be recorded as well as the 85 entries in the table and the cards can be quickly sorted for any desired set of characters.

Summary

A method is described by which the principal characters of a smut fungus can be summarized by a formula comprised of twelve numerals. The method is illustrated by formulae for the commoner British smuts.

I am indebted to Miss K. Sampson for supplying material and to those in charge of the Herbarium of the Royal Botanic Gardens, Kew, and the Herbarium of the Ministry of Agriculture's Plant Pathological Laboratory for allowing me access to specimens.

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APPENDIX

The formulae of some British smuts

Formula	Host	Smut
1001.2182.9015	*Agrostis*	*Tilletia decipiens* (Pers.) Körn.
1001.2182.9017	*Holcus*	*Tilletia Holci* (West.) Schroet.
1002.2182.7015	*Lolium*	*Tilletia Lolii* Auers.
1002.2182.8015	*Phalaris*	*Tilletia Menieri* Har. & Pat.
1003.1181.2010	*Oxyria*	*Ustilago vinosa* (Berk.) Tul.
1003.1182.5010	*Polygonum*	*Ustilago utriculosa* (Nees) Tul.
1015.1101.7010	*Carex*	*Cintractia Caricis* (Pers.) Magn.
1042.3132.2010	*Carex*	*Farysia olivacea* (DC.) Syd.
1111.1131.5015	*Polygonum*	*Sphacelotheca Hydropiperis* (Schum.) de Bary
2007.133*2.5210	*Convolvulus*	*Thecaphora seminis-convolvuli* (Desm.) Liro
2007.2182.6014	*Triticum*	*Tilletia Caries* (DC.) Tul.
3002.1112.3010	*Scilla*	*Ustilago Vaillantii* Tul.
3003.1181.2010	*Dianthus*	*Ustilago violacea* (Pers.) Rous.
3003.1181.3010	*Silene*	*Ustilago major* Schroet.
3004.1181.3010	*Scabiosa*	*Ustilago Scabiosae* (Sow.) Wint.
4001.1132.3010	*Bromus*	*Ustilago bromivora* (Tul.) Fisch. v. Wald.
4001.1182.4090	*Tragopogon*	*Ustilago Tragopogi-pratensis* (Pers.) Rous.
4002.1104.3010	*Avena*	*Ustilago Kolleri* Wille.
4002.1144.2010	*Arrhenatherum*	*Ustilago perennans* Rostr.
	Avena	*Ustilago Avenae* (Pers.) Jens.
	Hordeum	*Ustilago nuda* (Jens.) Rostr.
	Triticum	*Ustilago Tritici* (Pers.) Rostr.
4003.133*2.5190	*Carduus*	*Thecaphora Trailii* Cooke
4005.1104.3010	*Hordeum*	*Ustilago Hordei* (Pers.) Lagerh.
6001.1502.4192	*Allium*	*Urocystis Cepulae* Frost
6001.1502.5192	*Secale*	*Urocystis occulta* (Wallr.) Rabenh.
6001.1502.5292	*Agropyron*	*Urocystis Agropyri* (Preuss) Schroet.
	Colchicum	*Urocystis Colchici* (Schlect.) Rabenh.
6001.1502.5293	*Anemone*	*Urocystis Anemones* (Pers.) Wint.
6001.1502.5392	*Viola*	*Urocystis Violae* Fisch. v. Waldh.
6001.1502.6293	*Carex*	*Urocystis Fischeri* Körn.
6001.1503.5393	*Thalictrum*	*Urocystis sorosporioides* Körn.
6002.1101.1090	*Glyceria*	*Ustilago longissima* (Sow. ex Schlect.) Meyen
6002.1102.5090	*Gagea*	*Ustilago Ornithogali* (Schum. & Kunze) Magn.
6002.1132.3090	*Holcus*	*Ustilago striaeformis* (West.) Niessl
6005.1103.5090	*Linaria*	*Melanotaenium cingens* (Berk.) Magn.
6005.1103.6090	*Galium*	*Melanotaenium endogenum* (Ung.) de Bary
6007.1101.3010	*Ranunculus*	*Entyloma microsporum* (Ung.) Schroet.
6007.1101.40$\frac{3}{10}$0	*Dahlia*	*Entyloma Dahliae* Syd.
6007.1302.4590	*Trientalis*	*Tuburcinia Trientalis* B. & Br.
6007.1501.3696	*Sagittaria*	*Doassansia Sagittariae* (West.) Fisch.
6012.1102.1090	*Agropyron*	*Ustilago hypodytes* (Schlect.) Fr.
7002.1142.3090	*Zea*	*Ustilago Zeae* (Beck.) Ung.
7003.2182.6017	*Rumex*	*Ustilago Kühneana* Wolff
8002.1102.4010	*Scirpus*	*Ustilago marina* Durier.

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THE INVALIDITY OF THE GENUS *PYTHIOMORPHA*

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(With 2 Text-figures)

Introduction

In 1937 Dr M. P. Hall kindly presented to this laboratory a water-mould which she had collected on an apple dropped into a pond near Manchester and had later isolated and grown in pure culture. She had identified it as *Pythiomorpha gonapodyides* and we accepted it as such, since it showed the characteristic undulating hyphae and proliferating sporangia. The habitat was a likely one for *Pythiomorpha*. During the months of January to May in the two years when Dr Hall was collecting, the hydrogen ion concentration ranged from 6·0 to 8·0. This corresponded to the 'neutrally alkaline' and 'constantly alkaline' waters of Lund (1934), who found five species of *Pythiomorpha* in Denmark. It is true that this strain bore oogonia and antheridia in abundance, an unusual feature in *Pythiomorpha*; but Forbes (1935) had reported abundant sex organs on the material collected by her in Bristol and it was assumed that this was a similar strain.

It appeared to be favourable material for a full study of this little known genus, which was therefore undertaken by one and later by another of us. But as the investigation proceeded it became evident that there was not a generic difference between this isolate and the strain of *Phytophthora Cactorum* which had been under observation in this laboratory for many years and of which a detailed description was available. On the other hand there was no species of *Phytophthora* on record that occurred as a water-mould. It is true, there is the notice by Bewley and Buddin (1921) that the disease-causing organisms *Phytophthora cryptogea* and *Phytophthora parasitica* are transported in glasshouse water; and there is the description by Shanor (1938) of a new species of *Phytophthora* with proliferating sporangia viz. *Phytophthora stellata* Shanor, found on petals of *Rhododendron maximum* fallen into water at a high altitude in North Carolina. But concerning this last species Mr S. F. Ashby, who grew it and observed its spore formation, has suggested that it is a species of *Pythium*.

Mr Ashby at the Imperial Mycological Institute diagnosed Dr Hall's isolate as *Phytophthora megasperma*. This was confirmed by Dr Tucker. This then is the second record of a species of *Phytophthora* found growing as a saprophytic water-mould. The first tentative record is of *Phytophthora cryptogea* isolated by one of us from the water of the Hogsmill River and assumed at first to be *Pythiomorpha gonapodyides* (Waterhouse, 1940). In view of the widespread occurrence of the species of *Phytophthora* and their partiality for and dependence on water it seems surprising that no earlier records have been made.

Two questions naturally arose. Have species of *Phytophthora* been mistaken for *Pythiomorpha gonapodyides* on other occasions? Are the records of *Pythiomorpha gonapodyides* all of the same fungus? An attempt was made to procure a culture of *Pythiomorpha gonapodyides* for comparison. Petersen's and von Minden's strains were no longer in culture. Kanouse, we found on enquiry, had given up re-culturing her isolate but had sent a culture to the Centraalbureau of Schimmelcultures at Baarn. We obtained a subculture of this from Baarn in the summer of 1939; also an isolate of their own, identified as *Pythiomorpha gonapodyides*. The latter turned out to be a species of *Phytophthora*, the former to be a species of *Pythium*. This strain had the habit of a *Pythium*. It bore no sex organs, no sporangia but abundant chlamydospores. Sporangia were encouraged to form by culturing on prune in water according to the method given by Kanouse. First prosporangia formed and then secondary sporangia in which the zoospores matured. It was without doubt a species of *Pythium*. It was later discovered that Tucker (1931) had sent to Baarn for a culture. He wrote (p. 141): 'A culture of this fungus received from Baarn failed to produce either sporangia or oöspores and soon died. The mycelial development was more like *Pythium* than *Phytophthora*, but insufficient data were obtained to determine its relationships.' Drechsler (1930) too, wrote of Kanouse's strain. 'In the hands of the present writer the presumably identical organism never produced zoospores within the sporangium to discharge them full fledged through an orifice provided by a uniformly sessile papilla. On the contrary, development took place as in typical representatives of *Pythium*.' We reported our observation to Miss Kanouse, who in a letter dated 25 January 1941 agreed that some contamination had crept in and that what we had received from Baarn was a species of *Pythium*. So Kanouse's strain is lost too.

An enquiry into the literature revealed the very slender grounds on which the genus *Pythiomorpha* is separated from *Phytophthora*. The proliferating nature of the sporangia which was the outstanding characteristic of the new genus has since been shown to be a familiar feature of several species of *Phytophthora*. Other characters such as the undulating hyphae, the repetitional development of the zoospores,

the variable presence of a vesicle are all to be found within the genus *Phytophthora*.

This enquiry showed too that the validity of the new genus had been questioned on more than one occasion: Buismann (1927), Fitzpatrick (1930), Drechsler (1930 and 1931), Sparrow (1935). Meanwhile new species have been erected which has only added to the confusion. The matter seemed worth investigation.

The genera concerned

There are only two genera with which *Pythiomorpha* could be confused, viz. *Pythium* and *Phytophthora*, and these are undoubtedly closely allied to one another.

Pythium is marked out by the development of a prosporangium in which the protoplasm prepares for the formation of spores. At a certain stage this protoplasm is passed through a discharge tube into a secondary sporangium in which the zoospores mature. This secondary sporangium is sometimes called a vesicle.

Phytophthora differs from *Pythium* in one respect only, that the zoospores are matured within a sporangium which forms directly from a slender hypha. The sporangium may or may not produce an evanescent vesicle when the ripe zoospores escape.

Historical survey

Pythiomorpha gonapodyides was described by Petersen (1909, 1910) as a new genus and a new species and put into a new family Pythiomorphaceae in the Saprolegniineae together with Leptomitaceae and Saprolegniaceae.

The reason for the creation of *a new family* appears to have been negative. The presence of cellulose in the hyphal membrane, and of the refractive granules 'believed to be cellulin' in the protoplasm of the new species, presumably determined its inclusion in the Saprolegniineae although not in either of the two families which made up that cohort.

The genus was founded on the absence of a vesicle on emission of zoospores from the sporangium, and on the colour reaction of the hyphae with chlor-zinc iodine. 'Mycelium ramosum, membrana chlor. zinc. jodato rubro-violaceo colorata. Propagatio adhuc cognita zoosporis duobus ciliis lateralibus munitis, vesica non cinctis exeuntibus efficitur.' Petersen says elsewhere that with chloroiodide of zinc the membranes of the hyphae adopt exactly the same colour as hygroscopic cotton and the refractive granules are coloured yellow and finally dissolved.

The new species was founded on the 'intramatrical irregular, branched mycelium with irregular thickenings of the membrane',

and the proliferating sporangia. 'Mycelium intramatricale ramosum irregulariter tumoribus et parietibus undulatis instructum. Mycelium extramatricale hyphis erectis non ramosis diam. 4–5μ constat. Zoosporangia terminalia ovalia diam. *c.* 44μ × 22μ. Zoosporae ut *Saprolegnia* non vesica cinctae, ellipsoidae, duobus ciliis lateralibus munitae, diam. 10μ, exeunt. Hyphae in et per zoosporangia evacuata penetrant et nova sporangia repetite formant.' He did not observe oogonia and antheridia.

Petersen collected his new species from 'old apples in a pond in a garden in the neighbourhood of Glostrup in August 1902 and May 1903, and in the channel near Friederiksdal, and on alder in a pond of alders in the wood of Ruder Hegn, October 10, 1902'. He published drawings of the form of the mycelium but did not illustrate undulating hyphae. He gave one measurement of sporangia, viz. 22 × 44μ. In the same account of Danish Freshwater Phycomycetes Petersen listed under Pythiaceae in the Peronosporineae two species of *Pythium*, viz. *Pythium proliferum* de Bary 'on leaves and stems of old *Nymphaea* and on the decayed flower of a *Nuphar*', and *Pythium undulatum* sp.nov. on the same substratum. He stated that the new species of *Pythiomorpha gonapodyides* resembles *Pythium proliferum*.

Petersen's argument seems to have been that although his fungus resembled generally the members of the Pythiaceae it was not a species of *Pythium* because the zoospores were fully differentiated before leaving the sporangium: and it was not a species of *Phytophthora* because *Phytophthora* was not known to have proliferating sporangia. On the other hand, although his fungus gave reactions for cellulose in hyphal walls and contents, it could not be placed in either Leptomitaceae or Saprolegniaceae from whose members it differed in many morphological characters. Therefore a new family was required for it, lying somewhere between the Peronosporineae and Saprolegniineae.

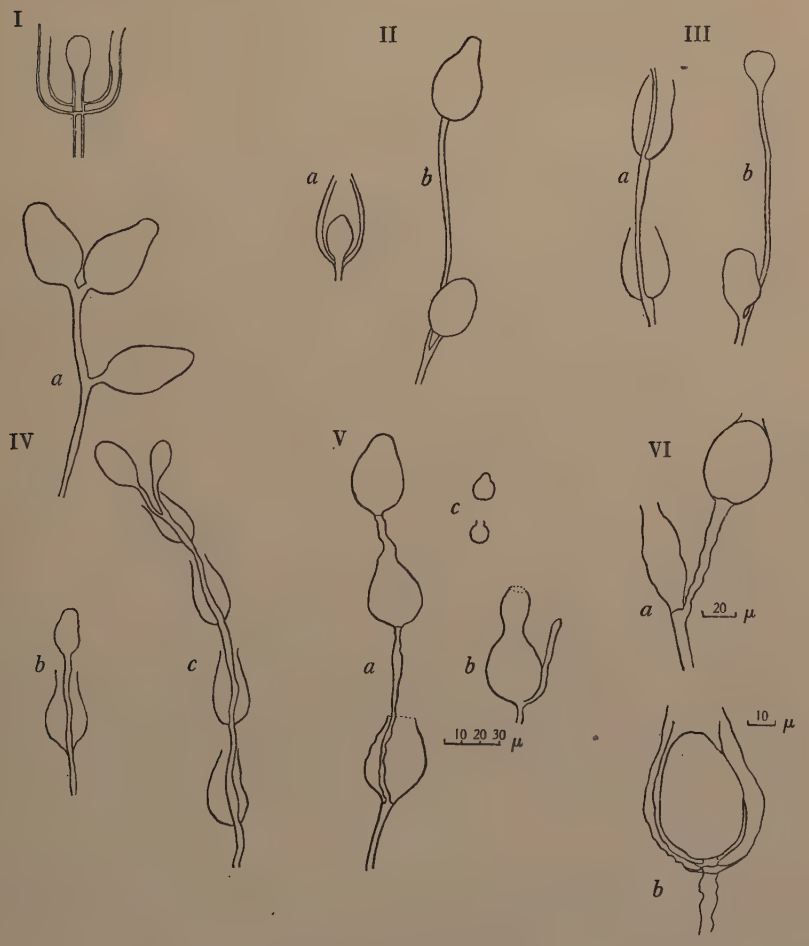
Seven years later von Minden (1916) claimed that he had frequently met with this water mould (which he called *Pythiomorpha* '*gonapodioides*' as did others after him), and that he could complete in some respects Petersen's original description. His account agrees with Petersen's except that he reported the emission of zoospores in an ephemeral vesicle, and a single occurrence of sexual organs on a slender mycelium, whose connexion with the sporangium-bearing mycelium he could not establish for certain, though it seemed extremely probable. Von Minden was critical of the establishment of a new family and genus for the new fungus, and pointed out that Petersen did not state his reasons very clearly. He admitted the similarity of the new species to the Pythiaceae in the mycelium, sexual organs, sporangium, and emergence of zoospores, but agreed in the retention of the new family Pythiomorphaceae on the grounds that

the mycelium showed knotted articulations and contained granules which might be the cellulin grains of the Leptomitaceae. In the present state of our knowledge, he said, it was a good idea to give it a place between these two families. Von Minden gave no measurements, and so one cannot be absolutely certain that he was dealing with the same fungus as Petersen.

There are no further records of *Pythiomorpha gonapodyides* until Kanouse (1925) reported it in a collection of water moulds in Michigan. She compared the hyphal growth with that of some species of *Phytophthora* and reported oogonia of an unusual type. Later (1927) she disposed of the family Pythiomorphaceae on the ground that if *Phytophthora* be included in the Pythiaceae, *Pythiomorpha* should be included too. But she still accepted the genus *Pythiomorpha*, stating that it differed from *Pythium* in three characters: absence of 'a tube or specialised beak', zoospores not formed 'in an exterior vesicle', zoospores 'truly diplanetic', and that it differed from *Phytophthora* in its 'diplanetic zoospores, in the absence of any conidial stage, and in its proliferating sporangia'.

Meanwhile, proliferating sporangia, already a well known feature within the genus *Pythium*, had been reported in species of *Phytophthora* by Pethybridge and Lafferty (1919) and by Rands (1922) (Appendix I) (Fig. 1).

At the same time that Kanouse was writing her monograph Buisman (1927) was investigating root rots caused by Phycomycetes. In her report she reviewed the position of the genera *Pythium* and *Phytophthora* and related forms: viz. *Pythiacystis* which had been incorporated in the genus *Phytophthora* by Leonian, and *Pythiogeton* which had been kept as a separate genus. The genus *Blepharospora* she critically examined in relation to *Phytophthora* and suggested that *Blepharospora cambivora* should be re-named *Phytophthora cambivora* on the ground that its chief characteristics, viz. (1) production of sporangia, in mineral salt solutions only and not on solid media, (2) long unbranched sporangiophores ending in one sporangium and proliferating through the empty sporangium, were exhibited by two well-established species of *Phytophthora*. This suggestion has been universally accepted. A similar suggestion that *Pythiomorpha gonapodyides* should be re-named *Phytophthora gonapodyides* on similar grounds has been either ignored or rejected by subsequent authors with the exception of Fitzpatrick (1930), Drechsler (1930 and 1932) and Sparrow (1935). Buisman maintained quite rightly that there was no character which justified the retention of a separate genus. In particular she noted that the reaction of chlor-zinc-iodine on the mycelium described by Petersen produced the same results with '*Blepharospora*'. Again the proliferation of the sporangiophores was a characteristic of both genera. On these grounds she suggested that the genus *Pythio-*



PHYTOPHTHORA

Fig. 1. Formation of new sporangia in *Phytophthora* (outlines traced and here reproduced). I. *P. cambivora* (*Blepharospora cambivora*) (after Petri), × 666. Formation of sporangia by proliferation. II. *P. cryptogea* (after Pethybridge and Lafferty), × 510. (*a*) Formation of sporangia by proliferation. (*b*) Sympodial branching of sporangiophore. III. *P. Richardiae* (after Buisman), × 366. (*a*) Formation of sporangia by proliferation. (*b*) Sympodial branching of sporangiophore. IV. *P. Cinnamomi* (after Rands). (*a*) Sympodial branching of sporangiophore. (*b*) Formation of sporangia by proliferation. (*c*) Formation of sporangia by proliferation and sympodially on the same sporangiophore. V. *P. megasperma* (after Drechsler). (*a*) Formation of sporangia by proliferation. (*b*) Sympodial branching of sporangiophore. (*c*) 'Diplanetism' of zoospores. VI. *P. Fragariae* (after Hickman). (*a*) Proliferation and sympodial branching of sporangiophore. (*b*) Formation of new sporangia by proliferation.

morpha should be merged with the genus *Phytophthora*. At the same time she described a new species of *Phytophthora*, *P. Richardiae*, with non-papillate proliferating sporangia produced only in liquid media, a characteristic which Petersen supposed was diagnostic for *Pythiomorpha*.

During the intervening and ensuing years other collectors of water moulds in various parts of the world, reported forms corresponding to Petersen's *Pythiomorpha gonapodyides*, notably Barnes and Melville (1932), Cook and Forbes (1933) in Britain: Sparrow in Britain and America (1932, 1935, 1936); Crooks in Australia (1937); Lund in Sweden (1934); Cejp (1932) in Prague; Höhnk (1936) in Germany. The measurements of the reproductive organs did not always correspond to those given by Petersen and Kanouse; sex organs were sometimes reported to be frequent although, according to Petersen, von Minden and Kanouse, they were characteristically rare; but the proliferation of the sporangia was always observed and deemed the distinguishing feature of the genus (Appendix II).

Apinis (1929), investigating the water moulds of Latvia, found a species with markedly undulating hyphae and large proliferating sporangia which emitted zoospores fully formed and not in a vesicle. Oospores were not present. He assumed that this fungus was identical with that named *Pythium undulatum* by Petersen (1909) and renamed it *Pythiomorpha undulata*, thus creating a second species in the genus *Pythiomorpha*. He gives no reason for this change. Sparrow (1932) reverted to the original nomenclature. He stated definitely that the change was not justified. Cejp (1932) collected and cultivated *Pythiomorpha* '*gonapodyoides*' and *Pythiomorpha undulata* in the hothouse of the Botanical Garden of the Charles University in Prague. He supported Kanouse in regarding this genus as occupying a unique position with 'diplanetism of zoospores, celluline, absence of a vesicle'. His knowledge that certain species of *Phytophthora* may show proliferation of sporangia did not deter him from recognizing a family Pythiomorphaceae. Lund (1934) found two forms in Denmark which he called respectively *Pythiomorpha undulata* and *Pythium undulatum*, the former 'common in bogs', the latter 'with doubt observed' in one locality.

It is possible that the investigators were not all dealing with the same fungus; that whereas Petersen and Sparrow had a species of *Pythium*, Apinis and Cejp had a species of *Phytophthora* and Lund had both. The distinction between the two genera lies in the mode of emission of the zoospores but it is difficult to tell from Petersen's description whether the 'vesicle' to which he refers is the true pythioid (secondary) zoosporangium or the evanescent vesicle sometimes seen in species of *Phytophthora*.

While investigating diseases of rice seedlings, Ito and Nagai (1931)

described two species of *Pythiomorpha*, viz. *P. Oryzae* and *P. Miyabeana*. They maintain the genus on the grounds given by Kanouse except that they did not find her 'di-planetic zoospores'. But there is nothing in their account in either word or picture to distinguish these fungi generically from *Phytophthora Fragariae* Hickman (1940).

Lund (1934) reported five species of *Pythiomorpha* from bogs in Denmark: *P. gonapodyides*, *P. undulata* and three un-named species. One of these three he suggests might be *P. Oryzae*, another might be *P. Miyabeana*. He did not observe zoospore emergence, but he did see zoospores fully differentiated within the sporangium. All three species have proliferating sporangia, which Lund regards as one of the distinguishing characters of *Pythiomorpha*, the other being absence of typical conidia. Forbes (1935) reported *Pythiomorpha* '*gonapodoides*' from near Bristol. She accepted the family Pythiomorphaceae and described oogonia and antheridia of the type of *Phytophthora*. Sparrow (1936) gave the species in a list of water moulds collected by him in the vicinity of Cambridge, England. Höhnk (1936) collected *Pythiomorpha* '*gonapodioides*' near Madison, Wis., U.S.A. and near Bremen in Germany. He identified it by its characteristic mycelium 'intramatrical threads distinctly constricted', and 'straight, thin, smooth and unbranched hyphae...developed only extramatrically'. He also observed 'refractive granules, believed to be cellulin'. From the same localities he collected a second form which produced new sporangia by cymose branching. For this he erected a new species *Pythiomorpha Fischeriana*. The fact that this is the typical method of sporangium formation in the genus *Phytophthora* and that Petersen originally established the genus *Pythiomorpha* on the proliferating nature of the sporangia emphasizes the fact that Höhnk's new form was a species of *Phytophthora*.

Critical analysis of the features claimed as diagnostic for the genus *Pythiomorpha*

A careful examination of the published descriptions of the genus *Pythiomorpha* reveals no outstanding feature by which it can claim equal rank with the three well-marked and universally accepted genera of the Pythiaceae.

The characters which have been described as diagnostic for *Pythiomorpha* are here reviewed and each shown to be a character shared with *Pythium* or *Phytophthora* or both of these.

(1) *Proliferation within the sporangium*

Proliferation is a widespread phenomenon in the family Pythiaceae. De Bary (1860) created a species *Pythium proliferum*, and since then several other species of *Pythium* have been shown to bear proliferating

sporangia viz. *Pythium diacarpum* Butler (1907), *Pythium undulatum* Petersen (1909), and four new species described by Drechsler (1930*b*), *Pythium helicoides*, *Pythium oedochilum*, *Pythium polytylum* and *Pythium paligenes*. All four species of *Pythiogeton* occasionally show proliferation (Drechsler, 1932), and eight species of *Phytophthora* have been reported as bearing proliferating sporangia in circumstances inducing a less vigorous growth in connection with a shortage of air (Appendix I) (Fig. 1).

This character then is by no means peculiar to *Pythiomorpha*. Nor is it even a constant feature of *Pythiomorpha*, for Ito and Nagai (1931) published an illustration of both sympodial and proliferating sporangia on one branch of *Pythiomorpha Oryzae*, and Höhnk (1936) went so far as to erect a new species, *Pythiomorpha Fischeriana*, for a form in which 'no proliferation was observed' (Fig. 2). On the other hand it is of interest to note that the most recently erected species of *Phytophthora*, viz. *Phytophthora Fragariae* has proliferating sporangia (Hickman, 1940). The evidence is clearly against proliferation as a character peculiar to *Pythiomorpha* and diagnostic for that genus.

(2) *Emission of zoospores within a vesicle*

All descriptions of *Pythiomorpha* agree that the zoospores are fully fashioned within the sporangium. Von Minden observed an evanescent vesicle but Petersen and others did not. This formation of the zoospores within the sporangium, with rare occurrence of an evanescent vesicle as they emerge, is the character which distinguishes the genus *Phytophthora* from the genus *Pythium*.

(3) *Irregular hyphae*

The intramatrical, irregular-branched mycelium with irregular thickenings of the membrane (Petersen, 1909), knotted, articulated threads (von Minden, 1916), budlike projections (Kanouse, 1925), undulating hyphae (Apinis, 1929), knob-like hyphae (Ito and Nagai, 1931), constricted hyphae (Höhnk, 1936), are all well-known and variable characters of species of *Phytophthora* and *Pythium*. Indeed Petersen (1909) himself erected a species, *Pythium undulatum*, having irregular hyphae. Illustrations of *Phytophthora megasperma* by Drechsler (1931), and of *Phytophthora Fragariae* by Hickman (1940), depict undulating hyphae, although this is not given as a diagnostic feature for *Phytophthora*. Nor can irregular, undulating hyphae be claimed as diagnostic for *Pythiomorpha*. Leonian (1934, Fig. 2) figured six growth forms of *Phytophthora Faberi* to illustrate how variable submerged hyphae can be.

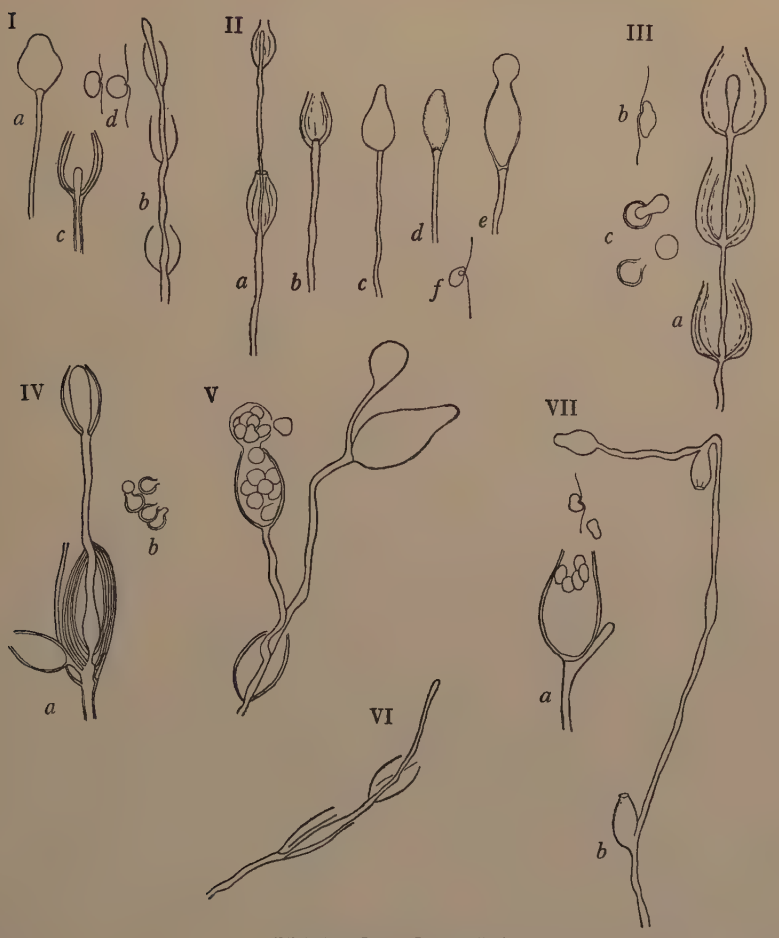


Fig. 2. Formation of new sporangia in *Pythiomorpha* (outlines traced and here reproduced). I. *P. gonapodyides* (after Petersen). (*a*) Typical zoosporangium (44 $\mu \times 22\mu$). (*b*) Proliferation of sporangiophore beyond empty sporangium. (*c*) Proliferation of sporangiophore within empty sporangium. (*d*) Zoospores (10 μ). II. *P. gonapodyides* (after von Minden). *a–f*. III. *P. gonapodioides* (after Kanouse). (*a*) Proliferation of sporangiophore. (*b*) Zoospore. (*c*) 'Diplanetism' of zoospores. IV. *P. undulata* (after Apinis), × 322. (*a*) Formation of new sporangia sympodially and by proliferation on the same sporangiophore. (*b*) 'Diplanetism' of zoospores. V. *P. Oryzae* (after Ito and Nagai), × 430. Formation of new sporangia sympodially and by proliferation on the same sporangiophore. VI. *P. Miyabeana* (after Ito and Nagai), × 430. Proliferation of sporangiophore. VII. *P. Fischeriana* (after Höhnk). (*a*) and (*b*) Sympodial branching of sporangiophore.

(4) *Microchemical reactions—cellulin grains*

Petersen (1910) wrote: 'By treating with chloroiodide of zinc the membranes of the hyphae adopt exactly the same colour as hygroscopic cotton. The protoplasm within the hyphae is highly refractive with distinct grains. The last-named are coloured yellow by chloroiodide of zinc, but are gradually dissolved by this substance. Hydrate of potassium does not influence them. Presumably they are identical with the grains we find in the Saprolegniaceae and Leptomitaceae and most probably they consist of cellulin.' Von Minden (1916) described the hyphae as having hyaline contents with little granules and on account of these cellulin grains he agrees with Petersen that *Pythiomorpha* must be classed between the Leptomitaceae and the Pythiaceae in a family of its own. Kanouse (1925) agreed that granules are always present, and Höhnk (1936) reported that 'the refractive granules, believed to be cellulin, were also observed; several 2–5, being situated between two neighbouring constrictions'. Others have not referred to these granules, and they appear to be an inconstant feature.

(5) *Absence of conidia*

Kanouse (1925) when augmenting Petersen's description of the genus, described the sporangia as true zoosporangia since they were never seen to function as conidia by the production of germ tubes. Later (1927) she cites the absence of any conidial stage as a feature distinguishing *Pythiomorpha* from *Phytophthora*. Subsequent workers in forming new species of the genus have accepted this and it has been reiterated by Lund (1934) as a diagnostic feature of the genus. Actually the absence of conidia is a feature of growth in water. A conidium in the Pythiaceae is a reproductive body resembling a sporangium in development and in shape, but germinating by a tube to give a mycelium. A conidium may or may not be abstricted from the mycelium. The asexual reproductive body characteristic of the genus *Phytophthora* may function either as a sporangium or as a conidium. It has previously been shown by two of us (1931) that the method of germination depends entirely on conditions such as age of mycelium and age of spore. Experiments have shown that it is primarily a sporangium and that only when frustrated in early production of zoospores, does it germinate by means of a tube. Among the aquatic members of the genus, zoospore production is the rule and conidia are rare; in *Phytophthora megasperma* Drechs. there is no mention of germination by a tube. On the other hand, *Pythiomorpha undulata* has been recorded as having conidial germination. This character cannot therefore be regarded as distinguishing the two genera.

(6) '*Diplanetic*' *zoospores*

This character claimed by Kanouse for *Pythiomorpha gonapodyides* is really the repetitional emergence of Atkinson (1909) and equivalent to the repetitional diplanetism described by Drechsler (1930) for six species of *Phytophthora*. It is a frequent feature of species of Pythiaceae as well as Saprolegniaceae in which latter family true diplanetism occurs, i.e. two unlike swimming forms. This character cannot therefore be regarded as one which would permit its use to distinguish the genus *Pythiomorpha* from either the genus *Phytophthora* or the genus *Pythium*.

(7) *The aquatic habitat*

The four species of *Pythiomorpha* are unquestionably water moulds. Now while species of *Pythium* have frequently been reported in collections of water moulds, species of *Phytophthora* have not. Yet it is a very likely habitat for *Phytophthora*. It is a common practice in the laboratory to induce the formation of sporangia in *Phytophthora* by immersing the mycelium in water, where it produces more slender hyphae, no typical conidia, but sporangia instead; and in the following species these tend to proliferate so that any of them might pass for *Pythiomorpha*: *Phytophthora megasperma*, *P. cryptogea*, *P. Richardiae*, *P. cambivora*, *P. Cinnamomi*, *P. Drechsleri*, and *P. Fragariae*. The drawings of the sporangia of *Pythiomorpha* by Petersen, von Minden, Kanouse and others (Fig. 1) suggest that it was not always the same species that was found growing in water.

Had Ito and Nagai not found their parasites on rotted rice seeds and seedlings in water, it is possible that the proliferating sporangia would not have been so much in evidence and the fungi would have been identified as species of *Phytophthora*. *Phytophthora megasperma* is well known as a parasite on plants in swampy ground. Does it live on in the water as a saprophytic water mould and is it transferred by water, and is that how it came to be collected by Dr Hall among water moulds? It seems that this must be one of the ways in which the diseases caused by species of *Phytophthora* are spread. It is generally recognized that some of the species of *Phytophthora* frequently infect plants in swampy ground, e.g. *P. megasperma* (Drechsler, 1931; Dowson, 1934; Tomkins, Tucker and Gardner, 1936) and *P. Richardae* (Buisman, 1927). It will also be remembered that the two species of *Pythiomorpha* isolated by Ito and Nagai (1931) were vigorous parasites, a feature not previously reported for *Pythiomorpha*. And if, as we firmly believe, the other three species are really parasitic members of the genus *Phytophthora* growing saprophytically in water, pathologists should now regard these water moulds as widespread and forming hitherto unsuspected sources of infection.

Conclusion

We claim then that there are no grounds for the retention of the genus *Pythiomorpha*. Petersen founded his new genus and species on the proliferating sporangia, the growth-form of the hyphae, and the presence of 'cellulin' grains in the thallus. Other diagnostic characters given by later workers are the aquatic habit, the diplanetic zoospores and the absence of true conidia. It seems likely that if Petersen had known (*a*) that species of *Phytophthora* could live saprophytically in water as water-moulds, and (*b*) that several species of *Phytophthora* bore proliferating sporangia (Appendix I), he might not have felt the need for a new species. After all he did name it *Pythiomorpha*, and said 'This species resembles *Pythium proliferum.*'

Moreover all these characters, except the presence of 'cellulin' grains, are commonly exhibited by a group of species of *Phytophthora*. But since there are species of *Pythiomorpha* without 'cellulin' grains, these can hardly be taken as the one diagnostic feature. It may however be claimed that while the characters of the genus *Pythiomorpha* are shared by various species of *Phytophthora*, *Pythiomorpha* is distinct in possessing *all* of them. But this is not so. *Phytophthora megasperma* possesses all of them (except for the variable cellulin grains). It might also be claimed that as we have not handled a bona-fide species of *Pythiomorpha* we are not in a position to appreciate its distinctive character (if indeed it has any), which justifies the retention of a separate genus. We have however handled four different isolations all identified as and claimed to be *Pythiomorpha gonapodyides*. One turned out to be *Phytophthora megasperma*, one a species of *Pythium* and the other two (from different countries) certainly species of *Phytophthora*, probably *P. cryptogea*. All this serves to emphasize the point we have tried to make, viz. that there has never been a bona-fide genus *Pythiomorpha* but that all the fungi described under this head have been different species of *Phytophthora* growing in water. If collectors have been examining different species of *Phytophthora* the discrepancies in descriptions found in the literature are explained (Appendix II). It is unfortunate that the early strains, those of Petersen, von Minden and Kanouse, are lost.

We feel we have collected together enough evidence to endorse the statements made by Buismann (1927), Fitzpatrick (1930), Drechsler (1930 and 1931), and Sparrow (1935) regarding the invalidity of the genus and recommend that no further species be created, that the five species already erected be re-examined and if not found to be known species of *Phytophthora* (or *Pythium*) that they be incorporated as new species into one or other of these well established genera. The collection of numerous examples of the so-called species of *Pythio-*

morpha from a variety of aquatic habitats and their incorporation into the genus *Phytophthora* (or *Pythium*), even their identification with existing species, will finally confirm our claim about which there can be no reasonable doubt.

Summary

A water mould collected on an apple in a pond near Manchester was identified as *Pythiomorpha gonapodyides* and obtained in pure culture.

In pure culture it was identified as *Phytophthora megasperma*.

This led to a survey of the descriptions of various forms and species of *Pythiomorpha* recorded between 1909 and 1936 and the discovery that each would answer to a species of *Phytophthora* growing in water. The descriptions of the original species *Pythiomorpha gonapodyides* varied so much as to suggest more than one species of *Phytophthora*.

This led to an enquiry into the diagnostic features of *Pythiomorpha gonapodyides* Petersen, and the discovery that all of these were equally characters of the Pythiaceae as a whole, i.e. there was no peculiar generic or indeed specific character.

It then appeared that there were no records of species of *Phytophthora* occurring as water moulds except a tentative one of *P. cryptogea* and the present one of *P. megasperma*. Nevertheless it was clear that several workers had already felt that the species of *Pythiomorpha* were probably species of *Phytophthora*, and the present study brings facts and illustrations in support of their conviction that the genus *Pythiomorpha* is invalid.

Grateful acknowledgements are due to Dr M. P. Hall for kindly sending the isolated strain to the laboratory of Royal Holloway College, to Mr S. F. Ashby and Dr Tucker for identifying the organism as *Phytophthora megasperma*.

We should like to thank Dr Leonian for a letter expressing his whole-hearted agreement that the genus shall be suppressed, and Mr S. F. Ashby for his support of our views.

While carrying out this enquiry (a side line of our other researches) one of us has been in receipt of a grant from the Department of Scientific and Industrial Research which is here gratefully acknowledged.

APPENDIX I

Species of Phytophthora *having proliferating sporangia*

Sporangia				Oospores		
Length	Breadth	Mean or average	Species	Range	Mean or average	Colour
60–75 μ	40–54 μ	67 × 47 μ	*P. cambivora* (Petri) Buisman after Petri (1918)	20–27 μ	23·5 μ	Sooty
24–50 μ	17–30 μ	40 × 27 μ	*P. cryptogea* Pethybr. & Laff. after Pethybr. & Laff. (1919)	Very rare	25 μ	Yellowish
25–100 μ	18–43 μ	57 × 33 μ	*P. Cinnamomi* Rands after Rands (1922)	None		
			after Ashby (1929)	Very rare	27·2 μ	
			after Tucker (1931)		25·7 μ	
	Variable		*P. Richardiae* Buisman after Buisman (1927)		29 μ	Oogonium yellow; Oospore greenish purple
			after Tucker (1931)		25·4 μ	Colourless
15–60 μ	6–45 μ	37·5 × 25·5 μ	*P. megasperma* Drechsler after Drechsler (1931)	11–54 μ	41·4 μ	
31–69 μ	18–42 μ	52 × 35·7 μ	after Blackwell, Waterhouse & Thompson	22–40 μ	38 μ	Yellow
41·6–56 μ	28–40 μ	49·4 × 33·6 μ	after Tomkins, Tucker & Gardner (1936)	26–40 μ	33·4 μ	
24–38 μ	15–24 μ	31·4 × 21 μ	*P. Drechsleri* Tucker after Tucker (1931)	16·7–45 μ	25·6 μ	Hyaline to lemon
32–90 μ	22–52 μ	60 × 38 μ	*P. Fragariae* Hickman after Hickman (1940)	22–44 μ	33 μ	Oogonium golden brown with age

Phytophthora erythroseptica should be included in this table. (Buddin, W. "Root rot, shoot rot and shanking of tulip caused by *Phytophthora cryptogea* Pethybr. & Laff. and *P. erythroseptica* Pethybr., *Ann. appl. Biol.* xxv, 1938, pp. 705–29.)

APPENDIX II

Records of species of Pythiomorpha

Sporangia			Species	Oospores		
Length	Breadth	Mean or average		Range	Mean or average	Colour
			P. gonapodyides Petersen			
		44 × 22 μ	after Petersen (1909)		None	
	No measurements		after von Minden (1915)		Few, doubtful origin	
26–48 μ	16–27 μ	37 × 21·5 μ	after Kanouse (1925)	22–36 μ	29 μ (Oogonia)	
			after Forbes (1935)		30 μ	Dark brown
		45 × 22 μ	after Lund (1934)		None	
		46 × 28 μ	after Höhnk (1936)		None	
			P. undulata (Petersen) Apinis			
50–167 μ	20–52 μ	108·5 × 36 μ	after Apinis (1929)		None	
45–117 μ	35–43 μ	70 × 40 μ	after Lund (1934)		None	
			P. Oryzae Ito & Nagai			
41–84 μ	26–48 μ	72 × 36 μ	after Ito & Nagai (1931)		None	
			P. Miyabeana Ito & Nagai			
36–53 μ	17–36 μ	47 × 26 μ	after Ito & Nagai (1931)	24–36 μ	30 μ	Yellowis
			P. Fischeriana Höhnk			
		46 × 28 μ	after Höhnk (1936)	20–28 μ (Oogonia)		
			Unnamed species Lund			
50–75 μ	35–52 μ		after Lund (1934)		None	
67–103 μ	42–56 μ		,,		None	
40–67 μ	30–42 μ		,,		None	

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FURTHER NOTES ON BRITISH HYPOCREALES

By T. PETCH

Since the publication of *British Hypocreales* in *Trans. Brit. myc. Soc.* xxi (1938), 243–305, several species have been added to the British list. These are recorded below, with further information concerning some of the rarer species previously recorded for this country.

Melanospora vitrea (Corda) Sacc.

In *J. Bot.* July 1936, p. 189, I published a note on this species, pointing out that Corda's fungus, *Sphaeronaema vitreum*, was a *Sphaeronaemella*, as then understood, and distinct from *Sphaeronaemella blepharistoma* Berk. I find that von Höhnel had previously considered these species, and had published a preliminary note in *Oesterreich. bot. Z.* Jahr. 1916, p. 96, in which he gave the name of a new genus, *Hyalopycnis*, with the species, *H. vitrea* (Cda.) v. H., *H. blepharistoma* (Berk.) v. H., and *H. hyalina* v. H. In *Hedwigia*, lx (1918), 151, von Höhnel further discussed these species. He had rejected the name *Sphaeronaemella*, on the ground that the type species of that genus was an ascomycete.

The three species named have the same structure. They resemble a *Melanospora* in shape, being globose below, with a long, cylindrical neck, but, except in the centre of the base, the wall is composed of vertically parallel, hyaline hyphae, fused laterally. Von Höhnel examined the type specimens of *H. blepharistoma*, and decided that it differed in shape from *H. vitrea* and was a distinct species. I redescribed it (*loc. cit. supra*) from fresh specimens. The evidence regarding *H. vitrea* is not altogether satisfactory, as no one has been able to find in recent specimens assigned to that species the peculiar spores described and figured by Corda. He stated that they were oval when viewed laterally, but quadrangular in section. von Höhnel suggested that what Corda saw were chlamydospores, but even so they have not been reported again.

In *Notices of British Fungi*, No. 196, Berkeley stated that he had found *S. blepharistoma* not only on *Russula adusta*, but also on nettle roots. I have specimens collected at North Wootton on decaying stalks of *Brassica* and Hollyhocks which resemble that species, but the spores are larger, 9–16 × 5–9 μ, sometimes cylindrical or fusoid, 10–16 × 2–3·5 μ, and the fungus appears to be another species of *Hyalopycnis*.

It may be noted that the type species of *Sphaeronaema* Fr. (1823), *S. subulatum*, has spores furnished with a cilium at the apex and a pedicel at the base. *S. oxysporum* Berk. is the same species. No other similar fungus has been recorded, and consequently *Sphaeronaema* is a monotypic genus belonging to the Nectrioidaceae. The name *Eleutheromyces* was given to an alleged ascosporic stage of *S. subulatum*, and it does not replace *Sphaeronaema*.

Sphaeronaemella

The genus *Sphaeronaemella* was instituted by Karsten in *Hedwigia* (1884), No. 2, with the description, Spermogonia subsphaeroid, membranous, very thin, soft, horny when dry, superficial, glabrous, light-coloured, with a rostellate ostiolum; extruded spores ellipsoid, continuous, forming a globule at the apex of the rostrum. No colour was given for the spores, but the type species, *S. Helvellae*, which occurred on *Helvella infula*, was said to have hyaline spores and a yellowish pycnidium, 120μ diameter, or 150μ high and 135μ wide, with a hyaline beak, 0·3–0·5 mm. high and 20–35μ diameter, penicillate at the apex. Saccardo entered it as a pycnidial fungus, as described, and it has been so interpreted by later mycologists. The name was used in that sense in *British Hypocreales*, p. 301.

In *Hedwigia*, LX (1918), 151, von Höhnel recorded that Diedicke had examined the type of *Sphaeronaemella Helvellae* and found that the wall of the globose base was parenchymatous, while that of the beak was composed of long-fibred tissue, and that there were no conidiophores. Von Höhnel therefore decided that it was an ascigerous fungus with diffluent asci, similar to *Ceratostomella*, but belonging to the Hypocreaceae. It is similar in shape to *Melanospora*, but has hyaline spores. He also placed *Sphaeronaemella fimicola* March. as a similar ascomycete. The last-named was recorded for Britain by Massee and Salmon on horse dung, and by Massee and Crossland on rabbit dung. Its description, *ex* Saccardo, is included here for reference.

Sphaeronaemella fimicola March. Perithecia scattered, rarely gregarious, superficial, globose, 150–250μ diameter, membranous, soft, yellowish, glabrous, produced into a subulate, cylindrico-conoid beak, 700–820μ long, hyaline and penicillate at the apex; spores ellipsoid, hyaline, slightly curved or straight, 7–7·5 × 2–2·5μ, involved in mucus, forming a white ovoid globule, 130 × 85μ, at the apex of the ostiolum. On dung.

Melanospora cirrhata Berk.

In *J. Bot.* LXXIII (1935), 224, I wrote 'Berkeley issued specimens in *British Fungi*, No. 325 (1843) as *Melanospora cirrhata*, but he did not publish a description. Subsequently, he decided that his

species was the same as *M. Zamiae* Corda, and placed that name on some of the specimens in his herbarium.' It was also stated that Corda's species was unknown, whereas it had already been re-identified by Mr E. W. Mason and described by him in *Annotated Account of Fungi received at the Imperial Mycological Institute*, List II, fasc. 2 (1933). After further examination of recent specimens of *M. Zamiae*, I am of opinion that Berkeley's view was correct, and that *M. cirrhata* is a synonym of *M. Zamiae*. *Gibsonia phaeospora* Massee is no doubt the same species.

Nectria ditissima Tul.

Tulasne first found his *N. ditissima* on beech. In his account of it he stated that it was '*N. coccinea*', the form that occurred on beech, and that to it belonged, at least in part, the *Sphaeria coccinea* of most writers on mycology, his list including Moug. & Nestler, *Stirp. Vog. Rhen.*, fasc. II, 1811, No. 180 (on bark of *Fagus*), Desmazières, *Pl. Crypt. France*, ed. 1, fasc. VIII, 1829, No. 380 (on thick bark of *Fagus*), and Currey in *Trans. Linn. Soc. Lond. Bot.* XXII, 282, No. 175, pl. 49, fig. 174.

Desmazières, No. 380, in Herb. Kew., is certainly *N. coccinea*, not *N. ditissima*; it has an evident ostiolum, the cells of the wall are comparatively large, and the apex of the ascus is truncate and thickened, with a pore. Moug. and Kestler, No. 180, has the apex of the ascus rounded, the spores uniseriate below, biseriate above, oval or narrow oval, 9–18 × 5–6 μ, and somewhat persistent, septate, branched paraphyses; this is *Dialonectria galligena*.

Currey's figure of the ascus shows a rounded apex and obliquely uniseriate spores, and is not that of *N. coccinea*. He stated: 'I am uncertain whether this is the true *coccinea* Pers. This plant and the var. *sanguinella* are named by Mr Berkeley.' The only specimen of '*Nectria coccinea*' in Herb. Kew. *ex* Herb. Currey is an American one marked '*Nectria coccinea* on apple. Mass.', but this is *N. cinnabarina* and does not agree with Currey's figure.

Phillips and Plowright recorded *N. ditissima* in *New and Rare British Fungi*, no. 154, March 1880, without host, date, or locality. Plowright's paintings of the fungus on canker in apple trees, King's Lynn, March 1884, now in Herb. Brit. Mus., are of *Dialonectria galligena*.

Nectria inundata Rehm apud Weese

This species was described by Weese in *Z. Gärungsphys.* I (1912), 146, from specimens 'auf Wasserbretten aus Tannenholz'. Rehm had named it in herb., but had not published a description. After the description Weese stated that he had also found it on wood of *Prunus Padus* in Berkeley's herbarium at Kew. He did not cite any collection number, date, or locality, and I did not find the specimen in the Kew

herbarium. Consequently, as it was uncertain whether it was British, it was omitted from *British Hypocreales*. The description is quoted here for reference.

Perithecia scattered, base generally somewhat immersed, globose to globoso-conoid, up to 300μ diameter, often collapsing when old, blood-red to dark red-brown, shining, smooth, rarely with a few projecting, thick-walled, short, brown hyphae, with a darker, usually almost black, hemispherical papilla up to 110μ high, 150μ broad, which is composed of parallel, thick-walled hyphae; asci clavate to almost cylindrical, truncate above, almost sessile, 85–100 × 11–14μ; ascospores ellipsoid to subfusoid, generally inequilaterally curved, ends rounded, hyaline becoming brown, smooth, one-septate, often slightly constricted, 13–20 (sometimes 24) × 5·5–7μ.

In a later note, *S.B. Akad. Wiss. Wien, Math.-naturw. Klasse*, Abt. 1, Bd. cxxv (1916), 507, Weese stated that because of its brown spores the fungus belonged to the genus *Letendraea*.

Nectria ochroleuca (Schw.) Berk.

Additional localities for this species are provided by specimens in Grove's herbarium. These are, on bark, Selly Oak, December 28, 1909; on a stump, Coleshill, September 8, 1886; and on seeds of horse chestnut, Birmingham, September 11, 1886. In the last-named specimen, the perithecia are accompanied by a conidial stage, which may take an isarioid form, white, about 0·5 mm. high, usually expanding fanwise from the base and terminating in a tangle of conidiophores, or a stilboid form, 0·5 mm. high, with a yellow pruinose stalk, 0·2 mm. diameter, and a white head, 0·3 mm. diameter. The conidiophore has a stout main stem, 4μ diameter, dividing above, each branch terminating in a small cluster of phialides, as in Seaver's figure of the conidiophore of *Creonectria seminicola*, which, according to von Höhnel and Weese, is the same as *N. ochroleuca*. The conidia are oblong or oval, 5 × 2μ or 4 × 3μ. Seaver gives the conidial stage of *N. ochroleuca* as *Verticillium tubercularioides* Speg., after examination of the type of the latter. *Nectria Hippocastani* Allesch., described from specimens on rotting seeds of horse chestnut, is not this species, judging from its description.

Nectria polyporina Petch, n.sp.

Perithecia caespitose, in dense clusters on an inconspicuous stroma, brick-red becoming dark red, appearing smooth, but minutely rugose when magnified, ovoid, 0·15 mm. diameter, 0·25 mm. high, apex conico-discoid or truncate when mature; asci clavate, apex truncate, 54–63 × 9μ, spores biseriate; paraphyses diffluent; ascospores usually fusoid, rarely narrow oval, one-septate (some two-septate), hyaline, verrucose, 12–15 × 4·5μ (one spore, 21 × 4μ). On the upper surface

of old *Fomes annosus*, the stromata emerging through cracks in the crust, North Wootton, August 10, 1936.

Peritheciis caespitosis, stromate inconspicuo, primo lateritiis dein fusco-rubris, levibus, sub lente minute rugosis, ovoideis, 0·15 mm. diam., 0·25 mm. alt., apice conico-discoideo v. truncato; ascis clavatis, apice truncato, 54–63 × 9 μ, sporis biseriatis; paraphysibus diffluentibus; ascosporis saepius fusoideis, raro angusto-ovalibus, uniseptatis (interdum biseptatis), hyalinis, verrucosis, 12–15 × 4·5 μ.

Dialonectria applanata (Fuckel) Petch, *comb. nov.*

Fuckel described this species as *Nectria applanata* in *Symbolae Mycologicae*, Nachtr. 1 (1871), 310. There are specimens in Grove's herbarium, 'on the remains of a sphaeriaceous fungus', Driffold Lane, 27 April 1882, and 'on a *Eutypa*', Blackwell, 22 March 1884; and I have others, on an effete pyrenomycete on sycamore, Steeton, Tadcaster, 19 April 1936 (W. G. Bramley), and on *Rhamnus catharticus*, Wheatfen Broad, 11 April 1940 (E. A. Ellis). The pycnidial stage, *Stylonectria applanata* v. Höhnel, was collected in May 1938 in Guiting Wood on *Diaporthe decedens* on hazel.

The perithecia are scattered or clustered, globose or oval, about 0·1 mm. diameter, typically with a flat apical disk which projects slightly over the body of the perithecium, bright red, becoming blood-red or almost black, subtranslucent, sometimes collapsing laterally; the asci are cylindrical, truncate, 70 × 4 μ, with uniseriate spores, and the ascospores oval or oblong-oval, smooth, hyaline becoming yellow, one-septate, 5–9 × 3–4·5 μ. The pycnidia are similar in shape and size, and the pycnospores resemble the ascospores, but are larger, 9–12 × 4–4·5 μ. In the available specimens, the pycnidia are more definitely applanate than the perithecia, the apex of the latter varying from discoid to conico-discoid or broadly conoid. This species may be passed over at first as *Dialonectria sanguinea*, but the smaller ascospores should arouse suspicion.

Dialonectria flammeola (Weese) Petch, *comb. nov.*

Weese described this species, as *Nectria*, in *Z. Gärungsphys.* 1 (1912), 142. There is a specimen in Grove's herbarium, 'on bark of *Latania borbonica*, Sutton (D.L.), 21. 2. 1888'. *Latania borbonica* is a commonly grown pot palm, the correct name of which is *Livistona sinensis*. *Dialonectria flammeola* belongs to the *Nectria haematococca* group, common saprophytic species in the tropics under many names, but it was originally described from European specimens on *Populus canadensis*. It is not known whether the present specimen grew in a greenhouse. The perithecia are superficial, scattered or gregarious, yellowish red, pruinose or minutely rugose, globose with a small conical ostiolum or globoso-conoid, 0·18 mm. diameter, sometimes

collapsing centrally, the outer layers of the wall consisting of red-brown, polygonal cells, up to 40μ wide, with tangentially elongated cells round the ostiolum. The asci are clavate, 50–66 × 4–7μ, with a truncate apex, and spores obliquely uniseriate, or uniseriate below and biseriate above. The ascospores are oblong-oval, hyaline, one-septate, smooth, 7–13 × 2·5–4μ.

Dialonectria galligena (Bres.) Petch

A specimen on ash, from Wells, Somerset, April 1938, was kindly sent me by Professor F. T. Brooks. The perithecia are on a canker on a twig about 5 mm. diameter.

Nectriella chrysites (Westend.) Sacc.

This species was recorded by Grove in *J. Bot.* xxiv (1886), 133, from specimens on twigs and small branches of ash, Middleton (Warwickshire), April, but he stated, 'It is not without a little uncertainty that I refer my specimens to this species, since the asci were imperfectly developed.' The identification was not correct.

Lasionectria lecanodes (Ces.) Petch

An additional locality for this species is Scolt Head Island, where it was collected on 30 May 1936, on *Peltigera polydactyla* by Mr E. A. Ellis.

Lasionectria Leptosphaeriae (Niessl) Petch

Specimens of this species were collected by Mr E. A. Ellis at Pool Carr, Wheatfen Broad, Norfolk, 19 December 1940, on *Leptosphaeria doliolum* on nettle.

Hyphonectria Solani (Reinke & Berth.) Petch

This species was included in *British Hypocreales* on a record by Pethybridge from Ireland. There is a specimen in Grove's herbarium, on rotting potato, Shirley, Warwickshire, 29 April 1914. The subiculum is scanty, white or ochraceous, and the perithecia are scattered or clustered, obpyriform, straight, or curved above, red to purple-red with a yellow obtuse apex, 0·5 mm. high, 0·25 mm. diameter, with spreading hyphae on the lower half and a few short, rigid, two-septate hairs, about 25 × 5μ. The crown figured by Reinke and Berthold on the apex of the perithecium was evidently a mass of extruded spores. The asci are cylindrico-clavate, 90 × 9μ, with a truncate apex, and the paraphyses are linear. The ascospores are uniseriate, oval or oblong-oval, smooth, hyaline, then pale yellow and minutely warted, one-septate, not constricted at first, slightly constricted when old, 12–18 × 6–8μ, ends not pointed, with some globose, continuous, 7μ diameter.

Hyphonectria violacea (Schmidt) Petch

This was recorded by Grove in *J. Bot.* xxiii (1885), 132, under the synonym, *Hypomyces candicans*, on *Stemonitis fusca*, Trickley Coppice, Warwickshire, September 1884. Examination of the specimen in Grove's herbarium shows that the identification was correct. The ascospores are oval or oblong-oval, ends rounded, one-septate, sometimes rough, 6–7 × 2 μ. The fungus has the general appearance of the common hyphomycete on *Stemonitis* and other myxomycetes, *Cephalosporium verticicolum* Petch, but that species has not been found in company with the perithecia of *Hyphonectria violacea*, and its conidia do not agree with those described by Tulasne for the latter. *H. violacea* was originally described on *Fuligo septica*, but it is evidently not confined to that host, and, from their descriptions, it would seem probable that *Hypomyces exiguus* Pat., on *Stemonitis*, spores 3–4 × 2 μ, *Nectria Rexiana* Ellis, on *Chondrioderma spumarioides*, spores 5–6 × 1·5–2 μ, and *Hyphonectria Raciborskii* Penz. & Sacc., on *Physarum didermoides*, spores 6·5–7·5 × 3 μ, are the same species.

Apiocrea chrysosperma (Tul.) Syd.

A perithecial specimen of this, on a *Boletus*, Coleshill Pool, 13 September 1894, in Grove's herbarium, has ascospores, 18–30 × 4–6 μ. It is thus the long-spored form.

Hypomyces aurantius (Pers.) Tul.

In *British Hypocreales* the name *Diplocladium penicillioides* Sacc. was adopted for the conidial stage of this species. In a sense, that was correct, for it is the name given by Saccardo to Cooke's figure of the conidial stage in Plowright's *Monograph of the British Hypomyces*. Saccardo, in his description of *H. aurantius*, stated that the conidial stage was *Diplocladium minus* Bon. or a closely allied species, but I discarded that name in view of Massee's statement that *D. minus* occurred on trunks. *D. minus*, however, was originally described as occurring on old polypori, and it is frequent in this country on that substratum.

The mycelium of *H. aurantius* may be white at first, becoming ochraceous or orange, or it may remain permanently white and bear pale honey-coloured perithecia. On further consideration it seems clear that *D. penicillioides* is *D. minus*, and that *D. melleum* (B. & Br.) Sacc. is the same species. Berkeley and Broome stated that *D. Rennyi* was very near *D. minus*, and Massee placed it as a synonym of the latter. No host was given for *D. Rennyi* by Berkeley and Broome, but in Saccardo, *Sylloge Fungorum*, it is said to occur on trunks. Mr E. W. Mason has kindly examined the type collection and has

informed me that one envelope contains bark and wood, but there does not appear to be any hyphomycete in that envelope.

RHYNCHONECTRIA LONGISPORA (Phil. & Plowr.) v. Höhnel

Phillips and Plowright described this species as *Eleutheromyces longisporus* in *New and Rare Fungi*, No. 289, 'Perithecia crowded, superficial, elongated, whitish yellow, 450–500 μ high by 200 μ wide at the base; ostiola acutely pointed; asci clavato-elongate or subfusiform, 130–150 × 20–25 μ, usually tetrasporous; sporidia hyaline, elongate fusiform, acute, uniseptate, with terminal cilia at both extremities, 50–60 × 5–8 μ. On the remains of some myxogaster. Holt House Woods, King's Lynn, 4th Sept., 1882. The acute ostiola are composed of a number of converging narrow straight cells placed side by side.' In Plowright's note-book the host is given, with a query, as *Cribraria argillacea*, and there is the entry, 'sketched', but the sketch, unfortunately, is not among his papers. It may have been sent to Phillips, but it was not published.

In *J. Bot.* 1907, p. 171, Grove recorded the occurrence of *Eleutheromyces longisporus* on the decaying plasmodium of a myxomycete, and placed it in a new genus as *Eleutherosphaeria longispora* (Phil. & Plowr.) Grove. But before that, in 1902, von Höhnel, acting on a suggestion by Saccardo in *Syll. Fung.* IX, 942, had instituted for it a new genus *Rhynchonectria*. Von Höhnel did not have a specimen.

Grove stated that the perithecia occurred in globular or discoidal masses, 0·25–0·5 mm. diameter, twenty to fifty in a cluster, their bases immersed in a slight layer of mucus and the long necks protruding in all directions. The perithecia were hyaline and whitish, faintly tinged yellow when older, globular or ellipsoid below, prolonged into a tapering neck; the venter was composed of large pseudoparenchyma, with cells 10 μ diameter, the cells becoming elongated upward, and reduced at the apex to six or eight narrow linear cells surrounding the orifice, the apex being as sharp as a needle but soon breaking off. The wall was one cell thick, except at the base. The perithecia were 400–500 μ high and 60–90 μ diameter below. The asci were clavato-fusiform, four-spored, 120 × 25 μ, soon diffluent, and the spores fusiform, acute at each end, hyaline, uniseptate, 60–70 × 8–10 μ, surrounded by a layer of mucus which holds the spores together after the diffluence of the ascus.

Grove noted that the perithecia in his specimen were not so broad, nor were the spores ciliate at both ends, as described by Plowright. He suggested that the mucus when dried might present the appearance of a cilium at the ends. That suggestion may be correct, for Plowright's first draft of the description is 'spores fusiform, lower end most attenuated, almost into a cilium'. It may be noted that Grove's figure *b* exactly resembles the cluster of spores in *Mycorhynchus*. In

reply to my query, Mr Grove informed me that there was no specimen of *Eleutheromyces longisporus* in Plowright's herbarium, and said he thought it would be impossible to preserve it dry.

If the spores of *Rhynchonectria* are really not ciliate, there does not appear to be anything to distinguish it from *Treleasia* Speg. (1896). Spegazzini figured the ascus of *Treleasia Sacchari*, the type species of the genus, as limoniform, i.e. broadly ellipsoid, with an apiculus at each end, and resembling Grove's fig. *b*. Unfortunately, Petrak and Sydow, who examined the type specimen, could not find any trace of the fungus on it now (*Ann. Myc.* XXXIII (1935), 166). The same is true of the types of *T. musicola* Speg. and *Copranophilus spinuliformis* Speg., the latter the type of a new genus which does not appear distinct from *Treleasia*.

All the foregoing fungi have a remarkable resemblance to *Mycorhynchus* Sacc. (1905). They have the same type of perithecium and the same kind of spores, but the spores are said to be in asci, whereas *Mycorhynchus* is regarded as a pycnidial fungus. A note on the resemblance of *T. Sacchari* to *M. Marchalii* was published in *Ann. Myc.* XXXIV (1936), 74, 75.

A fungus which appears to be *Mycorhynchus Marchalii* (Sacc.) Sacc. & D. Sacc. was collected at North Wootton, June 1935, on decaying stalks of *Brassica*. The pycnidia are clustered, superficial on, or partly embedded in, a delicate plectenchymatous pale brown stroma, from which they radiate in all directions, forming subglobose tufts up to 0·5 mm. diameter, or smaller and confluent in extended patches. The pycnidia are hyaline, elongated flask-shaped, with a venter 66 μ high, 40 μ diameter which merges into a long beak, up to 300 μ high, 25 μ diameter below, attenuated upwards to a point. The wall of the venter is membranous, parenchymatous, while that of the beak is composed of parallel hyphae, 4 μ diameter below, septate, fused laterally. The spores are fusoid, attenuated below, sometimes into a thin appendage, hyaline, centrally one-septate slightly curved, 40–63 × 6–7 μ, with a mucilaginous coat which swells up enormously in lacto-phenol. There is sometimes an obscure septum at the base of the spore, which may indicate that the appendage is, in part, a sporophore. The spores appear to be almost sessile on the base of the pycnidium. They emerge separately from the pycnidium, but after extrusion they frequently adhere side by side in clusters of two or four. *Mycorhynchus Marchalii* was said to have smaller pycnidia, longer and narrower spores (65–70 × 5·4–5·6 μ), and no mention was made of a stroma.

From the foregoing data it will be seen that several questions arise which cannot be decided until further material has been collected. Was Grove's fungus the same as Plowright's? Except for the ascus, Grove's description is good for *Mycorhynchus*. Are *Rhynchonectria* and *Treleasia* ascomycetes? It would appear from Plowright's and

Grove's observations that the former is, though neither states how the four spores are arranged in the ascus. *Treleasia* is much more doubtful, judging from the figures.

Calonectria xantholeuca (Kunze) Sacc.

This species was originally described as *Sphaeria xantholeuca* in Fries, *Syst. Myc.* II, 503, 'Sparsa, peritheciis erumpentibus conico-subrotundis albo-lutescentibus, villo delicato albido tectis. Minuta, mollis, subpellucida, ut videtur astoma et globifera. In caulibus Epilobii, Helvetiae.' It was redescribed by Karsten in *Symbolae ad Mycologiam fennicam*, II, 241, and it is the latter description which was taken up by Saccardo in *Syll. Fung.* II, 547. Karsten described the ascospores as two- to four-guttulate; hence Saccardo assumed that they would ultimately be one- to three-septate, and accordingly entered the species as *Calonectria*. But in numerous other similar cases in which Saccardo made that assumption the fungus has been found to be a *Nectria*, and consequently the true position of this species is doubtful, even if we grant that Karsten had Kunze's fungus. Karsten's specimens were on dried stems of *Trifolium medium*. The description appears to indicate a *Nectriella*, and, as Weese has suggested, it may be the same as *Nectriella Sambuci* (v. Hoehn.) Weese. *Calonectria xantholeuca* was recorded by Corner from Wicken Fen in *Trans. British myc. Soc.* XIX, 284, but the specimens have unfortunately been mislaid. As it is uncertain whether Kunze's fungus was a *Calonectria*, the name cannot be accepted without further evidence.

Calonectria Pseudopeziza (Desm.) Sacc.

This species was described by Desmazières in 1840 as *Sphaeria*, and was transferred to *Calonectria* by Saccardo in *Michelia*, I, 307. The description in Saccardo, *Syll. Fung.* is:—gregarious, small; perithecia globose, glabrous, smooth, subpapillate, apricot-coloured (*armeniaca*), then white (*eburnea*), collapsing and becoming concave; asci subhyaline; sporidia three to four, very large, elongated, straight or curved, four to seven septate. It was said to grow on decorticated wood, branches of *Laburnum*, and *Arundo Donax*, in France. Apparently it was a common species, but there are few later records. In Bommer and Rousseau, *Florule Mycologique des Environs de Bruxelles* (1884), 185, it was recorded on branches of *Robinia Pseudacacia*, Boitsfort, without comment, and in *Revision des Champignons dans les Pays-Bas*, Oudemans included a record by Mlle Destrée of its occurrence on the same host at The Hague, adding that he much regretted that he had not been able to study this species, which seemed to him too imperfectly known. The type specimen has apparently not been re-examined, and Weese, who has dealt with most of the earlier

species of *Calonectria*, does not appear to have published anything on this species. The description is scarcely sufficient for determination.

C. Pseudopeziza was recorded for Scotland on branches of laburnum in *Trans. Proc. Bot. Soc. Edinb.* xxx, 349, 1931. It occurred in 1924 on *Laburnum* affected with die-back in the Horticultural Gardens of the Edinburgh and East of Scotland College of Agriculture. It appears to be doubtful whether any perfect stage was observed, and no specimen appears to have been preserved. For these details I am indebted to Dr C. E. Foister. In view of the uncertainty regarding both the species and the record, the name should be deleted from the British list.

GIBBERELLA FLACCA (Wallr.) Sacc.

This species was recorded for England by Phillips and Plowright in *New and Rare Fungi*, No. 77, as '*Gibbera flacca* (Wallr.). On *Solanum Dulcamara*, bursting through the bark in clusters, which are composed of very minute perithecia.' In Plowright's note-book the locality is given as Hellgate Lane, Terrington, Norfolk, 24 April 1876, and he added to the record the comment, 'Too near *Gibb. pulicaris*.' The specimen is not now in Plowright's herbarium, nor in Herb. Kew. or Herb. B.M.

The fungus was described by Wallroth in *Flora Crypt. Germaniae*, II, 838, as '*Sphaeria flacca*; perithecia very crowded, small, ovate, black, shining, soft, obsoletely papillate, seated loosely on a thin, fleshy, pallid stroma, and simulating a pulvinate, subcircular, flaccid acervulus,...on *Solanum Dulcamara* and elder branches.'

Fuckel issued specimens on *Solanum Dulcamara* in *Fungi Rhenani*, No. 976. He stated in *Symbolae Mycologicae* that it was hardly different from *Gibberella pulicaris*, and did not give any spore measurements. In the copy of *Fungi Rhenani*, No. 976, in Herb. Brit. Mus. the perithecia are immature, but they appear to be *G. pulicaris*. Winter in *Rabh. Krypt. Flora*, cited *Fungi Rhenani*, No. 976, for this species, but he gave the ascospores as $23–28 \times 6\mu$, and his description appears to be that of *G. cyanogena*. A specimen in Herb. Plowright, Birmingham, marked '*Gibberella flacca* Wallr. Ad sarmentorum Solani Dulcamorae, prope Neuchatel (Helvetia), 9. 1876. Dr Morthier,' is *G. cyanogena*, with spores three-septate, $22–36 \times 6–7\mu$, the spore wall being collapsed between the septa.

Sydow, *Mycotheca Marchica*, No. 2358, *Gibberella flacca* on *Solanum Dulcamara*, Berlin, 9. 1888, has spores three-septate, $18–27 \times 6–7\mu$, rarely oval, one-septate, $36 \times 5\mu$, and the wall of the perithecium is rough with small cellular warts and projecting cells, in these respects resembling *G. cyanogena*, but the wall is violet-grey by transmitted light, and the fungus agrees with the description of *G. moricola*. In this specimen again, the wall of the spore is collapsed between the septa.

Wallroth's '*flacca*', however, refers to the group of perithecia, not to the spore.

Wollenweber gives the spores of *G. flacca* on *Solanum* as three-septate, $22{\cdot}7 \times 4{\cdot}5\mu$.

It would appear that the name, *Gibberella flacca*, has been applied to any *Gibberella* on *Solanum Dulcamara*, and in view of this confusion, and in the absence of any British specimen, the species was omitted from the list of British Hypocreales.

Gibberella pulicaris (Fr.) Sacc.

A specimen on elder, Bolton Percy, Yorks, 26 February 1938, coll. W. G. Bramley, has all the asci four-spored. The asci are $75–100 \times 9–12\mu$, and the ascospores $18–24 \times 6–10\mu$, dimensions which do not differ appreciably from those of the normal form.

Gibberella Buxi (Fuck.) Wint.

This was recorded in *British Hypocreales* on one occurrence. There is a specimen in Grove's herbarium on a box leaf with *Pseudonectria Rousseliana*, without date or locality, but presumably British.

Gibberella Zeae (Schw.) Petch

Only one British specimen of this species could be cited in *British Hypocreales*, on grains of wheat, Cockle Park, Northumberland. In Grove's herbarium there is a specimen on the culm of an undetermined grass from Longdon, near Lichfield, 3 September 1909. The grass stem is slender and the fungus is inconspicuous. It is probable that careful search will show that *G. Zeae* is not uncommon on native grasses. I have since received specimens on *Phragmites*, collected by Mr E. A. Ellis at Wheatfen Broad, Norfolk, August 1939.

Ophionectria cerea (B. & C.) Ell. & Everh.

This species occurs on effete Pyrenomycetes or on wood blackened by Pyrenomycetes. Mr E. W. Mason has kindly submitted to me specimens on beech, Ranmore Common, 10 June 1934, and 7 April 1937.

The perithecia are superficial, scattered or in small groups, minute, depressed globose, 0·12–0·18 mm. diameter, yellow-brown, irregularly rugose except round the ostiolum; the ostiolum is at first scarcely evident, then minute, conical and blackish; the perithecial wall is composed of small cells, yellow to brownish yellow by transmitted light; the asci are clavate, shortly stalked or almost sessile, the upper part of the wall strongly thickened, $70–90 \times 8–10\mu$, the spores in an overlapping bundle; the paraphyses are at first abundant, linear, branched, longer than the asci, finally diffluent; the ascospores are narrow fusoid tapering to each end, ends obtuse, straight or curved,

seven- to nine-septate, 40–50 × 3·5–4·5 μ. The perithecia are sometimes accompanied by hyphae (? conidiophores) of the *Cladosporium* type, which may occur round or on them.

This species appears to be widely distributed in Europe and North America, and has usually been recorded on *Diatrype Stigma*. It was originally described from North American specimens as *Sphaeria cerea* Berk. & Curt., and Seaver has given the synonyms, *O. Everhartii* Ell. & Galw. and *Calonectria fulvida* Ell. & Everh. Though I have not seen type specimens, it is apparently *O. episphaeria* Karst., *O. Briardi* Boud., and *Calonectria belonospora* Schroet. *O. Briardi* was said to have very minute hairs on the perithecium, but as these were described as 20–60 μ long and 5–6 μ diameter they were probably the hyphae referred to above. The English specimens agree completely with the original description of *Calonectria belonospora* in *Krypt.-Flora Schlesien*, III, (2) (1894), 261, where Schroeter remarked that the groups of perithecia were usually situated in a brown tomentum composed of brown hairs, 3–4 μ diameter, but that it was uncertain whether these belonged to the *Calonectria* or to its host. It is probable that the minute tufts of brown hyphae which sometimes occur on old *Diatrype Stigma* belong to this species.

Pleonectria Lamyii (Desm.) Sacc.

This species was recorded, as *Nectria*, by Phillips and Plowright in *New and Rare Fungi*, No. 211 (*Grevillea*, x, 70), with the description, 'Perithecia caespitose, dark cinnabar red, rugose; ostiola minute, depressed; asci oblong, substipitate, octosporous, 0·074 × 0·014 mm.; sporidia oblong lanceolate, but obtuse at both ends, obscurely uniseptate, hyaline, 0·02 × 0·008 mm. Flitcham Abbey, King's Lynn, July 1881. On dead branches of *Berberis vulgaris*.' The description of the ascus and spores agrees with that of Fuckel in *Symbolae Mycologicae*, where the spores are described as uniseptate, i.e. as *Nectria*, not as *Pleonectria*. Dr J. Ehrlich informed me that he had examined the British specimen in Plowright's herbarium and found that it was *Nectria cinnabarina*. Consequently, there is no known occurrence of *Pleonectria Lamyii* in this country.

Cordyceps sphecocephala (Klotzsch) Cooke

The conidial stage of this species, *Hymenostilbe sphecophila* (Ditm.) Petch, was found by Mr E. A. Ellis on an ichneumon among flood refuse at Horsey Mere, 5 May 1938.

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ON THE HISTORY AND DIAGNOSIS OF *POLYPORUS TOMENTOSUS* FRIES, *POLYPORUS CIRCINATUS* FRIES AND *POLYPORUS DUALIS* PECK

By W. R. HADDOW

(With Plate VI)

1. Introduction

Among the brown Polypori perhaps none are more difficult to name with confidence than *Polyporus tomentosus*, *P. circinatus*, and *P. dualis*. Often described as rare, these plants are common enough in the coniferous forests of northern Ontario. They are the cause of a characteristic and destructive butt-rot of their hosts, a parasitic disease which in certain types of spruce forest has a very considerable silvical significance.

A collection of one of the above is readily recognized as such, but which of the three names is applicable, is a question hard to answer. Correct diagnosis is perplexing, not so much on account of difficulty in identification, for the use of the microscope has facilitated this, but because of the existence of inharmonious descriptions of the species in authoritative works. This is particularly true in America, where the common acceptance of Peck's species, *P. dualis*, in spite of his own ultimate rejection of it as of specific rank, has added to the confusion existing with respect to *P. tomentosus* and *P. circinatus*.

While European mycologists for the most part have consistently preserved in their writings the essence of the original descriptions of *P. tomentosus* and *P. circinatus*, opinion is not unanimous that both species are valid. Moreover, with the amplification of the descriptions in later years to embody microscopic characters, certain discrepancies have appeared therein. Thus Patouillard (1900), figuring the hymenial elements of what he calls *Xanthochrous circinatus*, showed that species with rather bulbous, short, straight setae. Konrad & Maublanc (1926), on the other hand, have figured a plant under the name of *Fomes* (*Xanthochrous*) *circinatus* with setae strongly curved. As for *Polyporus dualis*, it has never been recognized in the European flora, and some European mycologists have relegated the name to synonymy under *P. circinatus* (Cooke, 1886; Saccardo, 1888).

Among American authors there is little agreement about the

number of species involved, their geographical range, or their specific characters. Thus Murrill (1904) united *P. tomentosus* Fries, *P. circinatus* Fries and *P. dualis* Peck under the name *Coltricia tomentosa* and described the plant as common to Europe and America. Lloyd, on the other hand, treating the forms under *Polystictus*, stated that *Polyporus tomentosus* was not found in America. He referred American plants to *P. circinatus* or *P. dualis*, both of which he considered good species. Neuman (1914), however, described *P. tomentosus* from Wisconsin, but gave *P. dualis* as a synonym. Overholts (1933), Shope (1931) and Lowe (1934), in recent publications, have all followed Lloyd in relegating *P. tomentosus* to Europe—a mistaken assumption—but these writers are not unanimous with respect to the status of *P. dualis*.

The above suggests a lack of proper discrimination among the forms involved. Under such circumstances, a careful examination of the original descriptions of the plants and a comparative study of authentic specimens is called for. The present paper comprises a brief historical review of the species concerned, and the results of original comparative studies in the field in Ontario, and of herbarium specimens from North America and Europe.

2. Historical

Polyporus tomentosus[1] was described by Fries in his *Systema Mycologicum* and again briefly in the *Epicrisis*. In subsequent notes (1849), he adds details with a view to distinguishing this plant from *Polyporus circinatus*.

The Friesian description of *P. circinatus* which is usually cited is that given in his *Monographia Hymenomycetum Sueciae* of 1863. Actually much earlier ones exist under the name *Trametes circinatus*. Thus the first,[2] in Fries's *Fungi Natalenses*, is inserted rather irrelevantly among the descriptions of certain Wahlberg collections from Natal. The actual

[1] *Polyporus tomentosus*, inaequalis, pileo suberoso azono stipiteque tomentosis fulvis, poris minutis aequalibus, albido-cinnamomeis. Valde irregularis; plerumque caespitoso-concrescens imbricatus, subexcentricus, stipite brevi, sed et solitarius, stipite longiori; nunc centrali, nunc laterali. Substantia primo spongioso-mollis, priorum crassior. Pori semper rotundi, obtusi, integri. In silvis ad terram, raro.

[2] *Trametes circinatus* inter *Trametem Schweinitzii* et *Tr. perennenem* medius, eisdem locis ac prior obvius, inter folia abiegna coacervata in silvis densissimus. Stipes subaequalis, unciam longus et fere crassus, durus, ferrugineo-tomentosus cum acubus pineis concrescens. Pileus spongioso-suberosus, ob superficiem dense et intertexto tomentosam tactu mollis, subvelutinus, prorsus azonus, explanatus, disciformis, 3–4 unc. latus, fulvo-ferrugineus, margine orbiculari integro. Contextus ferrugineus; inferne filamentosus, lignescens; superne floccosus spongiosus. Pori 3 lin. longi, minuti, integri, nec ut *Tr. perennis* lacerati, tantum ore inaequali, fusco-grisei, intus fusci; trama tenuissima sed manifeste e pilei substantia.

station of *Polyporus circinatus* was, of course, in the vicinity of Upsala. Again, in the *Summa Vegetabilium Scandinaviae* (1849), *Trametes circinatus* is listed along with *T. perennis* and *T. tomentosus*; and in a footnote it is described at some length as a newly discovered species.[1] Fries's figure of *Polyporus circinatus*, pl. 180, fig. 1 of the *Icones selectae Hymenomycetum* (1884), is a very poor representation, and does not agree with his descriptions in several respects.

The Friesian descriptions, though incisive, have proved to be inadequate for definitive purposes. They contain, of course, no reference to microscopic characters. The distinction between *Polyporus tomentosus* and *P. circinatus* is drawn from their gross appearance, and consists essentially in the nature of the context (which in the former is alleged to be homogeneous, and in the latter duplex), and in the relative depth of the pore layer—characters of dubious diagnostic value. Moreover, it is not possible to distinguish type specimens of the above. Fries never designated such—indeed he rarely kept the common Swedish fungi that he knew, though he often sent samples to Berkeley and others. In this instance, certain specimens have been preserved, although there is to-day no authentic material among Fries's collections at Upsala (sec Nannfeldt).

We turn now to *P. dualis*[2] described by Peck from New York in 1878. Here, too, the description refers only to gross characters, and one is struck by its similarity to that given for *P. circinatus* by Fries. It should be noted that Peck himself came ultimately to regard this plant as of varietal status, publishing the name *P. circinatus* Fr. var. *dualis* Pk. (1895). He had already described another variety *proliferus*, which is no longer commonly recognized. The type of *P. dualis* is preserved in the New York State Museum at Albany.

It should be clearly borne in mind that none of the original descriptions contained any reference to the microscopic characters of the plants. Since then, however, valuable diagnostic criteria have been discovered in the character of the setal elements in the hymenium,

[1] Novam hanc insignem speciem Upsaliae sub densis abietibus legi, omnino regularem, stratu duplici pilei, superiori spongioso molli *Tr. Schweinitzii*, inferiori suberoso duro *P. tomentosi* insignem. Pileus planus, stipesque tomentosi, ferriginei, sed pori valde elongati, tenues, fusci, ore cinereo regulari, praesente tamen trama angustissima pilei ut in seq., nec crassa praecedentium.

[2] *Polyporus* (Anodermei) *dualis* n.sp. Pileus dimidiate, sessile or sometimes produced behind into a stem-like base, convex or nearly plane above, somewhat uneven, rarely with a slight zonate appearance, single or caespitosely imbricating, two to four inches broad, nearly as long, tawny or tawny-ferruginous, the margin sometimes paler; flesh concolorous, the upper stratum of a soft spongy-tomentose texture, the lower firm and fibrous; pores minute, unequal, more or less angular, with thin dissepiments, whitish and denticulate on the edge, about equal in length to the thickness of the flesh of the pileus, dark ferruginous with a whitish or silvery reflection. Dead trunks of spruce trees. Adirondack Mts. Also at the base of pine trunks. West Albany. August and September.

and modern descriptions have been influenced accordingly. Unfortunately, most of the modern descriptions have been based on unauthentic specimens, and the criteria with respect to the setal character, now recognized as most valuable in diagnosis, have been employed indiscriminately. The current confusion is traceable directly to this cause, as can be clearly shown by following the history of the several species.

Polyporus tomentosus Fries

In Karsten's earlier work (1876) this plant was not recorded. In 1882 he described it under *Polystictus*, a disposition later adopted by Saccardo. He later (1889) transferred it to his new genus *Onnia*, members of which were distinguished from those belonging to *Polystictus* by the presence of setae in their hymenia. The essential specific diagnostic character of *Onnia tomentosa*, the type of the genus, was given as a homogeneous context, as distinct from the duplex one of *O. circinata*. No reference was made to the shape of the setae of either plant.

It is appropriate to refer here to pertinent work of Ellis and Everhart. In 1889 these authors founded the genus *Mucronoporus*, of which the type was *M. circinatus*. This was coincident with the establishment of *Onnia* by Karsten, and the two names are synonymous. The authors gave an account of a certain specimen received from the Canadian botanist Macoun from Prince Edward Island. It resembled *Polyporus tomentosus* Fr. but was thought at first to be a new species, on account of having setae in its hymenium, for no one had heretofore described these organs in *P. tomentosus*. But the authors go on to say that specimens of the latter, received ex herb. Karsten, were found to possess setae of the same type as those in Macoun's plant, which was then confidently referred to *Mucronoporus tomentosus*. It is figured in Pl. 8, and the setae are shown somewhat bulbous, but definitely straight (Ellis & Everhart, 1889).

Among modern American authors, Murrill is the only one who, in treating these species, has referred to authentic specimens. He stated that 'the types of *Polyporus tomentosus* at Upsala correspond in all respects with the plants found in America, having the same kind of spines and a dual context'. According to Prof. Nannfeldt there is actually no authentic material of either *P. tomentosus* or *P. circinatus* at Upsala, and it is a matter of uncertainty, therefore, what specimens Murrill actually examined. The plant named *Coltricia tomentosa* by Murrill is described by him as possessing setae more or less curved; but he cites the figure of Ellis and Everhart, already referred to, in which the setae are shown straight.

As already stated, Lloyd (1908) considered that *Polyporus tomentosus*

was a European species, not found in America. In describing the setae he implied that they were curved—'the same as in *P. circinatus*'. Neuman (1914) reported *P. tomentosus* from Wisconsin, but gave no description of the microscopic characters of the specimen. He gave *P. dualis* as a synonym, which leaves doubt as to the correctness of his diagnosis. Overholts (1933), following Lloyd, does not recognize *P. tomentosus* in the American flora, and Shope (1931) and Lowe (1934) are of the same opinion. In their recent publications, therefore, there is no treatment of this species.

In a little-known paper, Sartory and Maire (1922) suggested that *P. tomentosus* comprised a number of varieties of which *P. circinatus* is one. ('*Pol. tomentosus* Fr. doit probablement constituer un type auquel se rattache *P. circinatus* Fr. comme forme speciale.') They coined the cognomen '*Polyporus tomentosus* Fr. forme *circinatus* Fr.', and in variant form '*Pol. tom.* (var. ?) *P. circinatus* Fr.' They also published '*Polyporus circinatus* var. (?) ou forme: *Polyporus triqueter* Fr.' under which are united *P. triqueter* Fr. and *P. leporinus* Fr., which are considered forms of *P. tomentosus*. According to Lloyd, *P. leporinus* is the same as *P. dualis*, but it is doubtful whether *P. triqueter* belongs to this alliance. I have seen no authentic specimens, but Fries's figure, pl. 187 of the *Icones*, cannot be reconciled.

Curiously enough, Sartory and Maire did not discover the importance of the shape of the setae in the diagnosis of *P. tomentosus* and *P. circinatus*—a circumstance due perhaps to the inaccessibility of authentic specimens to them.

Polyporus circinatus Fries

Karsten (1889), in treating this plant under *Onnia*, noted the occurrence of setae in the hymenium, but did not describe their form. Ellis and Everhart (1889) described the setae of their *Mucronoporus circinatus* as curved. Patouillard (1900), on the other hand, figured what he called *Xanthochrous circinatus* with straight setae. Bourdot and Galzin's description (Bourdot and Galzin, 1927) conforms closely to the original but is amplified to describe the setae as either straight or curved. Konrad and Maublanc (1926) figure *Polyporus circinatus* under the name *Fomes* (*Xanthochrous*) *circinatus* with setae curved or hooked, and describe the organs as either straight or curved. They state that some consider it a variety of *Polyporus tomentosus* Fries, but that others hold it to be distinct.

Among American authors *P. circinatus* has received peculiarly perverse treatment. Lloyd at first (1908) described it as having straight setae, though later (1912) he said that they were curved 'as in *Polystictus tomentosus*'. He questioned whether '*P. circinatus* as found

in America' is really identical with the European plant of that name, and again whether *P. tomentosus* and *P. circinatus* are specifically distinct, suggesting that the alleged homogeneous context of the former might be characteristic of only young plants. Murrill referred it to his *Coltricia tomentosa* (1904).

Overholts, in his latest treatment (1933), states that all American forms should be referred here, and describes the typical form as having setae not curved. Shope (1931) holds the same view, and has figured a straight seta for *Polyporus circinatus* describing the organ simply as 'pointed'. According to Lowe, the setae are 'usually straight', but this author does not refer all his collections to *P. circinatus*; he considers *P. dualis* a good species.

Polyporus dualis Peck

This plant was described from New York in 1878. Cooke (1886) and Saccardo (1888) relegated the name to synonymy under *Polystictus circinatus*, and Peck himself came at last to regard it as a variety of that species. He continued to believe that it merited some distinction on account of its sessile or short lateral-stemmed habit and the comparatively high colour which dried specimens were said to display. It has never been recognized in the European flora, but many American mycologists regard it as a valid species. Ellis and Everhart (1889), describing a specimen received from Peck, noted that the setae were the same as in *Polyporus circinatus*, which they described as curved and regarded it as a form of the latter. Lloyd (1908), however, after examining the type, considered it distinct. He remarked that he had collected it himself in Temagami, Ontario, along with *Polystictus circinatus*. He noted that the setae were curved. Neuman (1914) believed, on the other hand, that *Polyporus dualis* was conspecific with *P. tomentosus*. Overholts assigned it finally to varietal rank under *P. circinatus*, on account of its curved setae—organs which according to him are straight in the typical form. According to Shope (1931) *P. dualis* is the same as *P. circinatus*, but Lowe (1934) considers it a good species, distinguished by its strongly curved setae.

A summary of the views of several American authors with respect to these plants is presented in Tables 1 and 2.

Table 1. *Disposition and range*

Author	*P. tomentosus* Fr.	*P. circinatus* Fr.	*P. dualis* Pk.
Ellis & Everhart (1889)	(Under *Mucronoporus*) Europe and America	Europe and America	=form of *M. circinatus* America
Murrill (1908)	(Under *Coltricia*) Europe and America	=*C. tomentosa*	=*C. tomentosa*
Lloyd (1908)	(Under *Polystictus*) Not found in America	Europe and America	America
Lloyd (1912)	=*P. circinatus*?	'*P. circinatus* of America' =*P. circinatus* of Europe?	
Neuman (1914)	Europe and America	Europe and America	=*P. tomentosus*
Shope (1931)	True *P. tomentosus* not in America. *Coltricia tomentosa*=*P. circinatus*	Europe and America	=*P. circinatus*
Overholts (1933)	Not found in America	Europe and America	=*P. circinatus* var. *dualis*
Lowe (1934)	True *P. tomentosus* not in New York. *Coltricia tomentosa* and '*P. tomentosus* of most Amer. authors, not Fr.'=*P. circinatus*	Europe and America	America

Table 2. *Diagnostic criteria*

Author	Context	Setae	Spores
	P. tomentosus Fr.		
Ellis & Everhart (1889)	—	Straight	—
Murrill (1904)	Duplex	More or less curved	5–7 × 2–4 μ
Neuman (1914)	Uniform by inference	—	—
	P. circinatus Fr.		
Ellis & Everhart (1889)	—	More or less curved	—
Lloyd (1908)	Duplex	Straight	5 × 3 μ Amer.
Lloyd (1912)	—	Curved	12 × 7 μ Eur.
Neuman (1914)	Duplex	—	—
Shope (1931)	Duplex	Pointed	4–6 × 3–4 μ
Overholts (1933)	Duplex	Straight	4–6 × 3–5 μ
Lowe (1934)	Duplex	Usually straight	4·5–5·5 × 3–4 μ
	P. dualis Pk.		
Ellis & Everhart (1889)	—	More or less curved	—
Lloyd (1908)	Duplex	Curved	—
Overholts (1933)	Duplex	Curved	—
Lowe (1934)	Duplex	Curved	6–7 × 4–5·5 μ

3. Authentic specimens[1]

It is extremely doubtful whether Fries preserved the plants from which he drew the descriptions of *Polyporus tomentosus* and *P. circinatus*. He was, of course, ignorant of the value of type specimens, and particularly of the value which was later to be put upon his own collections. Unfortunately there are no types or other authentic specimens of *P. tomentosus* or *P. circinatus* at Upsala. But there exist elsewhere specimens collected and named by Fries, which in the absence of designated types may be selected as typical. Such it has been my privilege to see.

In the Curtis herbarium, under the Farlow herbarium at Harvard University, there are the following specimens:

(1) *Polyporus tomentosus* Fries. The sheet consists of two specimens, one of which is labelled in Fries's hand '*Polyporus tomentosus* Upsala, Fries'. The other is in Curtis's hand '*Pol. tomentosus* Fr. Upsala Sweden. Fries misit Berkeley.' The specimens are of rather young plants, now somewhat worm eaten, but easily recognized. They both have straight setae.

(2) *Polyporus circinatus* Fries. This specimen is labelled in Fries's hand, and dated Upsala, 1849. The name has been over-written in pencil '*Trametes circinatus*'. It represents a rather old plant with a relatively deep pore layer and curved setae.

In the New York State Museum at Albany, the type of *Polyporus dualis* is preserved. It consists of abundant material of a large, old, almost sessile laterally attached form, having a well-developed pore layer and curved setae. After examining it I unhesitatingly refer it to *P. circinatus* Fries.

4. Discussion

From an examination of authentic specimens and a comparative study of many collections from Europe and America, I have concluded that two closely similar forms exist, common to Europe and America, namely, *Polyporus tomentosus* Fries and *P. circinatus* Fries. *P. dualis* Peck is identical with the latter. Both forms vary considerably in size, habit, stratification of the context, depth of pore layer, etc., according to age and habitat; and cultural experiments have shown that each form comprises several strains which differ conspicuously among themselves in cultural characters. With respect to the structure of

[1] Since the above section was written, I have received through the courtesy of the Imperial Mycological Institute, a report on certain specimens ex herb. Berkeley, in the herbarium of the Royal Botanic Gardens, Kew. While no authentic material exists there, it may be noted that, according to my correspondent, Mr E. W. Mason, the Swedish collections labelled *Polyporus tomentosus* have straight setae, while the only specimen under *P. circinatus* has curved setae.

the context, whether homogeneous or duplex, it has been found that all specimens exhibit a duplex structure. The relative thickness of the two layers, however, varies enormously, which has led to the description of certain specimens as with homogeneous context. The lower stratum is comparatively hard, sometimes turning vitreous when dried, and is composed of more or less straight radiating hyphae. The upper stratum is soft, and composed of hyphae which, though derived from those of the inferior layer, are crooked, branched and more or less erect, the whole forming a loose felty tomentum, often of considerable thickness. The typical difference between the forms is in the shape of the setal elements of the hymenium, which, in *P. tomentosus* are straight, and in *P. circinatus* strongly curved or hooked. There being no other reliable diagnostic criterion, *P. circinatus* may well be regarded as a variety of *P. tomentosus*.

By way of summary, I have ventured to redefine the species *P. tomentosus* and its variety *circinatus*:

Polyporus tomentosus Fries. Pileus stipitate, rarely truly sessile; stipe central, eccentric or lateral, often thick, short and irregular, tomentose; pilei often proliferating, and typically enmeshing conifer needles, dead twigs, etc.; soft coriaceous when fresh, drying rather hard, though light and brittle with a soft and friable upper surface; colour ochraceous, becoming rust-coloured with age; whitish below, especially towards the margin; azonate or faintly zonate; top plane or depressed, circular or flabelliform; margin acute or thicker in young plants, sterile below, often almost white; context golden yellow to brown, duplex in structure, the upper stratum tomentose, the lower radiately fibrous and silky, sometimes drying vitreous; lower stratum thick or very thin; tubes short, decurrent, the mouths circular to angular in older plants, often irregular in size, 2–4 per mm.; spores hyaline or pale yellowish, smooth, ovate, apiculate, variable in size 2·2–3·5 × 4·0–6·8 μ; setae abundant, 40–60 × 10–12 μ straight in the typical form. Usually on the ground under conifers, sometimes on the host. Europe and North America.

Polyporus tomentosus var. *circinatus* Fries. As in the typical form, but with setae strongly curved or hooked.

5. Specimens studied

(*a*) *Polyporus tomentosus*

Forest Pathological Collections, Department Lands and Forests, Ontario. Specs. 189, 191, 192, on *Picea mariana*, near Oba, Ont.; spec. 622 on *Pinus Strobus* stump, Marten Lake, North Bay, Ont.; spec. 623 on ground at base of *Picea* stump, Marten Lake, North Bay, Ont.; spec. 624 on ground near stump of *Pinus Strobus*, Marten Lake, North Bay, Ont.

Herbarium, University of Toronto. Spec. 2006 on *Picea canadensis* roots, Bear Island, Temagami, Ont.; spec. 5757 on ground, Bear Island; spec. 7724 on ground, Cattle Island, Temagami, Ont.; spec. ex herb. Univ. of Michigan Isle Royal

Exped. 1930, F.P. 531, labelled *P. circinatus*; spec. ex Polyp. of N. Amer. distr. by N.Y. Bot. Gard., 1907, labelled *Coltricia tomentosa*; spec. ex herb. J. H. Faull No. 1277, Adirondack Mts.

Herbarium J. H. Faull (all labelled *Coltricia tomentosa*). Spec. 6037 on ground attached to conifer root; spec. 3171 on ground attached to buried conifer root, Temagami, Ont.; spec. 5207 on root of *Picea mariana*, Temagami, Ont.; spec. 3637 on ground in conifer forest, Priest River, Idaho, coll. J. R. Weir; spec. 6090 on ground attached to roots of *Picea*, Temagami, Ont.; spec. 4723 on ground attached to conifer roots, Temagami, Ont.; spec. 4731 attached to roots of *Picea mariana*, Temagami, Ont.; spec. 464 Muskoka, Ont.; spec. 1469 on ground among conifers, Reynoldsdale, Pa.; spec. 1254 under *Pinus*, Toronto, Ont.; spec. 3257 on buried conifer root, Temagami, Ont.; spec. 3528 on ground in conifer forest, Cleland Twp., Ont.; spec. 3255 on stump of fallen balsam, Temagami, Ont.; specs. 5165, 3220, 3248 on ground in conifer forest, Temagami, Ont.; spec. 1277 Seventh Lake, Adirondacks, N.Y.; spec. 3298 on ground under *Pinus Strobus*, Rondeau Park, Ont.; spec. 8866 at base of *Picea mariana*, Oba, Ont.

Farlow Herbarium, Harvard University (in the Curtis Herbarium). Spec. labelled in Fries's hand: '*Polyporus tomentosus* Upsala, Fries'; spec. on same sheet labelled in Curtis's hand: '*Pol. tomentosus* Fr. Upsala, Sweden. Fries misit Berkeley.'

(*b*) *Polyporus tomentosus* var. *circinatus*

Forest Pathological Collections, Department Lands and Forests, Ontario. Spec. 188 on *Picea mariana*, near Oba, Ont.; spec. 190 on *Picea mariana*, near Oba, Ont.; spec. 453 on *Pinus Strobus*, Lundy Twp., Ont.; spec. 634 on ground, under *Pinus resinosa*, Temagami, Ont.

Herbarium, University of Toronto. Spec. 2009 on *Picea mariana*, Temagami, Ont.; spec. 5912 on ground, Little Cross Lake, Temagami, Ont.; spec. 5913 on ground, Temagami, Ont.; spec. ex herb. Penna State Coll., Centre Co., Penna, under *Pinus rigida*, labelled *P. circinatus* Fr. var. *dualis* Pk.; spec. ex herb. L. O. Overholts No. 13773, State Coll. Penna on *Pinus rigida* roots; labelled *P. circinatus* var. *dualis*; spec. F.P. 51495 on *Picea rubra*, Great Gulf, N.H., coll. P. Spaulding labelled *P. circinatus dualis*.

Herbarium, J. H. Faull (the following are labelled *Coltricia tomentosa*): spec. 8607 on living red pine, Temagami, Ont.; spec. 8063 at base of *Picea mariana*, Temagami, Ont.; spec. 3188 on ground under *Pinus*, Temagami, Ont. (The following are labelled *Coltricia dualis* (Peck) (Faull)): spec. 5180 on stump of *Pinus Strobus*, Temagami, Ont.; spec. 1278 on trunks of *Pinus Strobus*, Cornell Univ., Ithaca, N.Y.; spec. 5226 on stump of *Pinus resinosa*, Temagami, Ont.; spec. 8602 at base of living *Pinus resinosa*, Temagami, Ont.; spec. 1255 on trunk of *Pinus Strobus*, Ithaca, N.Y.; spec. 399 on stump of *Pinus Strobus*, Port Credit, Ont.; spec. 3414 on dead *Pinus pungens*, Hendersonville, N.C. (G. F. Atkinson); spec. 1479 on dead conifer wood, Reynoldsdale, Pa.; spec. 3473 on dead conifer wood, East Angus, P.Q.

Farlow Herbarium, Harvard University (in the Curtis Herbarium). Spec. labelled in Fries' hand: '*Polyporus circinatus*, Upsala 1849.'

New York State Museum. Type spec. *Polyporus dualis* Peck.

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EXPLANATION OF PLATE VI

Fig. 1. Setae of *Polyporus tomentosus*. Specimen from the Curtis Herbarium under the Farlow Herbarium, Harvard University, labelled in Fries's hand: '*Polyporus tomentosus* Upsala, Fries'. (× 125.)

Fig. 2. Setae of *Polyporus tomentosus* var. *circinatus*. Specimen from the Curtis Herbarium labelled in Fries's hand: '*Polyporus circinatus* Upsala 1849'. (× 125.)

Fig. 3. Setae of *Polyporus tomentosus* var. *circinatus*. Specimen from New York State Museum, Albany, N.Y. type of *Polyporus dualis* Pk. (× 125.)

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Fig. 3

Fig. 2

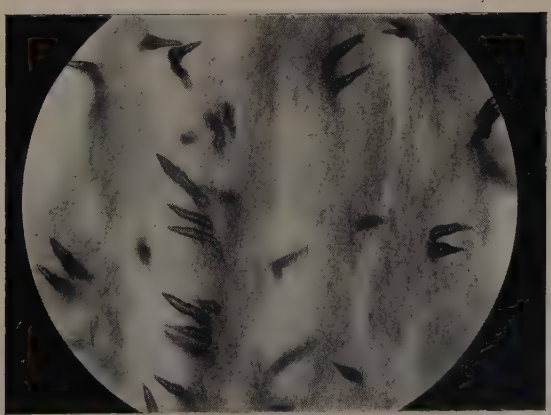

Fig. 1

AN ADDITION TO THE FUNGUS FLORA OF BARRO COLORADO ISLAND

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Barro Colorado Island, about six square miles in area, is located in Gatun Lake in the Panama Canal Zone. Formerly a hilltop overlooking the Chagres River, the island was created in 1913–14 when this stream was dammed, and the rising waters flooded the surrounding lowlands to form Gatun Lake. Owing to the opportunities for research afforded by the establishment of a permanent biological station on Barro Colorado, the island has been visited by numerous investigators with the most varied of interests.

It has been stated by Standley (1933), referring to the phanerogamic flora, that 'Barro Colorado Island is perhaps the most thoroughly known area of equal size in all tropical America'. Comparatively little is known, however, concerning the fungus flora of the island, although some 130 species, mostly Ascomycetes and Basidiomycetes, are listed by Standley (1933) from collections made by himself and others, notably Weston. Weston (1933) has written a semi-popular account of the fungi of Barro Colorado, in which are included representative forms of most of the principal groups, based upon a six months' visit to the island. Stevens (1927, 1928) has studied especially the sooty moulds, and Martin (1938, 1939) has devoted considerable attention to collections of Heterobasidiomycetes from Barro Colorado.

Concerning the Phycomycetes, however, and especially the aquatic forms, very little information is at hand. Weston has made a detailed study of the water moulds of the island and the surrounding Gatun Lake from an ecological as well as a taxonomic point of view, but the results of this investigation have not as yet been published.

In the summer of 1940, Mr Nevin Scrimshaw made a two months' visit to the island for the purpose of studying tropical fishes in their natural surroundings, and made a number of collections at my request. It was desired to secure samples of soil to be examined for the presence of aquatic fungi. Some sixty samples from all parts of the island, complete with data concerning soil temperature, *p*H, and other ecological factors, were collected only later to be lost. The

present report is based on thirty-six soil collections, without accompanying data other than the date and locality of collection.[1]

From nine of these soil samples, aquatic fungi were isolated in water culture on boiled hemp seed. All of the isolates obtained proved to belong to the genus *Allomyces* (Butler, 1911). These nine *Allomyces* isolates were obtained from Lutz Creek, from the shore of the bay in which the laboratory is located, and from the shore of the bay immediately to the north of the latter. One isolate (designated Panama 23) was obtained from a brackish stream near the ruins of Old Panama, about five miles from Panama City. All of the successful collections were made by Mr Scrimshaw on 8 and 9 August 1940.

Measurements of the resistant sporangia of each of the nine *Allomyces* isolates were made according to a procedure previously described (Wolf, 1941 *a*, *b*). The results, as presented in the accompanying table, show a remarkable similarity in the size of the resistant sporangia of the eight isolates from the island, while those of the single isolate from Old Panama are only slightly smaller and perhaps not significantly so.

Masses of the resistant sporangia were removed from the water cultures, allowed to dry on pieces of filter paper, and after several weeks were germinated. The resulting mycelia, in each of the nine isolates, bore the paired orange and greyish gametangia characteristic of *Allomyces arbuscula* Butler (1911) emend. Hatch (1933, 1935). This was the only species to appear in the present collections.

A. arbuscula has not hitherto been reported from the island, although it is not uncommon in other tropical portions of the western hemisphere. It has been found in Mexico (Wolf, 1939), Cuba (Wolf, 1941 *a*), Costa Rica, Haiti, and the Dominican Republic (Wolf, 1941 *a*, *b*). There is no appreciable difference in the size of the resistant sporangia or the characters of the gametangia in the Barro Colorado isolates of *A. arbuscula* and collections of this species from the other localities mentioned. It is to be regretted that, owing to the small number of soil samples at my disposal, only a single species was encountered in the collections. It seems safe to predict, however, that a more thorough and extensive survey of the aquatic fungi of the island might well result in the finding of many new or otherwise interesting forms.

[1] The writer desires to express his most sincere thanks to Mr Scrimshaw for his generosity and cooperation in making these collections available for study.

Table 1. *Measurements of the resistant sporangia of the* Allomyces *isolates from Barro Colorado Island and vicinity*

Isolate	Species	Width (mode in μ)	Length (mode in μ)	75% more between Width (μ)	75% more between Length (μ)
B.C.I. 7	*A. arbuscula*	35	43	32–37	40–49
B.C.I. 9	„ „	35	45	31–37	42–48
B.C.I. 12	„ „	35	47	33–40	43–52
B.C.I. 13	„ „	35	45	32–39	42–50
B.C.I. 15	„ „	37	49	34–41	44–52
B.C.I. 16	„ „	35	48	32–39	44–52
B.C.I. 21	„ „	33	45	30–37	40–49
B.C.I. 22	„ „	36	45	32–40	40–49
Panama 23	„ „	31	43	30–36	40–48

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BULB ROT OF *SCILLA NUTANS* CAUSED BY *PENICILLIUM CYCLOPIUM* WESTLING

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I. Introduction

During the summer of 1938 a consignment of Dutch-grown bluebells (*Scilla nutans*) intended for physiological experiments was found to be useless for this purpose since a large proportion showed rotting of the bulb scales associated with the presence of a species of *Penicillium*. As an alternative supply, bulbs were obtained from woods in England. Some of these were also found to be rotted though not so severely as were the Dutch bulbs. Imported bulbs of *Scilla campanulata* showed a similar rot.

An investigation of the cause of this disease and of the possibility of controlling it was undertaken. During this investigation a similar disease of *S. campanulata* var. *albida* imported from Holland was described by Macfarlane (1939) who identified the causal fungus as *Penicillium cyclopium* Westling.

II. Occurrence and symptoms

No information is available of the condition of the bulbs when lifted in Holland, since, when these are received in this country for planting (i.e. in August or September), rotting if present is usually far advanced. It is not known whether this rotting is present when the bulbs are lifted or whether it develops as a result of conditions during transport. A stock of bulbs originally obtained from Holland was grown at the Imperial College Field Station, Slough, and lifted in August. A few of these bulbs showed small wet brown spots on the surface of the bulb scales. Other bulbs which appeared to be clean when lifted developed similar spots during storage. These lesions enlarged and became depressed. A white mycelial growth developed in the centre of the lesion and was followed by the formation of a mass of blue conidia of a *Penicillium* type. In the later stages the rot progressed inside the bulb leaving a hard shrunken yellowish brown crust at the surface over the rotted area. When such a bulb was cut open the interior showed a wet rot with abundant *Penicillium* spores. Some bulbs became entirely rotted and were then covered

with spores and often infested with mites. A few bulbs became shrunken and showed a dry type of rot but later masses of spores developed as in the more normal type.

A stock of infected bulbs was graded as follows:

(*a*) With small lesions, sometimes showing spores of *Penicillium*.

(*b*) With larger and deeper lesions, usually showing spores of *Penicillium*.

(*c*) With dry rot, associated with the presence of *Penicillium* spores.

(*d*) With severe wet rot, covered with masses of *Penicillium* spores.

A hundred bulbs of each grade (with the exception of grade (*d*) of which only thirty-six bulbs were available) were planted in November in a light well-drained soil. Their performance during the growing season and gain or loss of weight when lifted in the following summer were as shown in Table 1.

Table 1

Grade*	Bulbs planted	Plants produced	Plants which flowered	Flower spikes	Weight increase of bulbs %
(*a*)	100	95	58	80	+33·3
(*b*)	100	78	27	33	−43·3
(*c*)	100	77	18	25	−38·0
(*d*)	36	7	1	1	−93·3

* For explanation see text.

It is clear that the grades (*a*)–(*d*) represented a series of increasing severity of attack. Bulbs of grade (*a*) (i.e. with small lesions only) showed satisfactory growth and flowering and were more or less sound when lifted. At the other end of the series very few of the severely rotted bulbs (grade (*d*)) produced a plant and those which did grow were stunted, with yellowish foliage and few or no flower spikes. Some of these plants died down before flowering.

III. Isolations from diseased bulbs

Isolations were made from bulbs showing the symptoms described above, and also from others with indefinite small lesions, in order to discover the earliest stages of infection. Small pieces of diseased tissue were plated out in the usual manner and cultures were also made from single spores of *Penicillium* occurring on the bulbs. Isolations were made from a total of 194 bulbs. Of these, 120 (including all those with typical well-developed lesions) yielded a species of *Penicillium*. Miscellaneous fungi (chiefly species of *Fusarium* and *Trichoderma*) were isolated from bulbs with small indefinite lesions. It is clear that species of *Penicillium* predominated. All the isolates of this fungus were similar and it was concluded that they belonged to a single strain.

IV. Morphology and identification of the species of *Penicillium* isolated

Penicillium sp.[1]

(*a*) *General characters.*

On Czapek's agar medium, colonies deep, spreading, blue-green becoming brown with age, margin of colony wide, at first becoming yellowish green and finally blue-green; colourless drops later becoming yellowish brown scattered over surface of colony; medium at first pale yellow, later brown-purple; crystals found scattered abundantly in the medium; odour strong, mouldy.

Optimum temperature for growth is approximately 20° C.

(*b*) *Microscopic features.*

Vegetative hyphae, 2·5–7·4 μ (av. 4·6 μ) in diameter; in older cultures swellings at the apex and also in the middle of the hyphae, 10–25 μ in diameter; penicillus 45–75 μ in length; conidiophores verrucose, arising from aerial and submerged hyphae, single, or in clusters or fascicles, 3·7–4·6 μ (av. 4·3 μ) in diameter, two branches arising from the apex of the conidiophore, verrucose, 10–25 μ in length and 3·7–4·6 μ (av. 4·3 μ) in diameter.

Metullae verrucose 9·3–13·9 μ (av. 11·7 μ) in length and 3·7–4·6 μ (av. 4·3 μ) in diameter.

Sterigmata with well-defined apical tubes, 7·4–10·2 μ (av. 9 μ) in length and 2·5–2·8 μ (av. 2·7 μ) in diameter.

Conidia, globose, smooth, in straight or tangled chains, 2·8–3·9 μ (av. 3·4 μ) in diameter.

The strain of *Penicillium* isolated from *Scilla* bulbs was compared with a strain of *Penicillium corymbiferum* Westling from the stock collection of the Plant Pathology Department, Imperial College of Science and Technology, and with strains of *Penicillium* isolated from *Iris* and *Lilium* bulbs. In the *Lilium* strain and in *Penicillium corymbiferum* (which were identical) the majority of the conidiophores were in fascicles and coremia were frequently formed. The majority of the conidiophores in the *Scilla* and *Iris* strains, on the other hand, were single and no coremia were formed. It was therefore concluded that these isolates were strains of *Penicillium cyclopium* Westling, and this was supported by the size of the conidia which were rather larger than those of *P. corymbiferum*. The above description also agrees essentially with that given by Macfarlane (l.c.) for *P. cyclopium* isolated from *Scilla campanulata*.

[1] The terminology used is in accordance with Thom's Monograph (1930) *The Penicillia*.

V. Inoculation experiments

Bulbs of *Scilla nutans*, free from lesions, were washed in 95 % alcohol, soaked for ten minutes in a 0·1 % solution of mercuric chloride and finally washed in sterile water and dried. A piece of agar culture was then placed on the surface of the bulb or was inserted in a wound which was afterwards sealed with paraffin wax. Pieces of plain agar were similarly applied to controls. A few bulbs of *S. campanulata* were also used. Other bulbs were sterilized as described above and were then washed in sterile water and soaked for fifteen minutes in a suspension of spores of the *Penicillium*. Controls were soaked in water. The bulbs were placed on pieces of wet cotton-wool and stored for two weeks in sterile jam jars plugged with cotton-wool.

Table 2

Bulbs inoculated	Strain of *Penicillium* used	Mode of inoculation	No. inoculated	No. rotted
Scilla nutans	*Scilla*	Wounded	36	36
	Scilla	Not wounded	24	0
	Scilla	Soaked spore suspension	9	0
	Iris	Wounded	15	15
	Lilium	,,	5	5
S. campanulata	*Scilla*	,,	10	10
Iris (Wedgewood)	*Scilla*	,,	15	15
	Iris	,,	15	15
	Lilium	,,	5	5
Lilium regale	*Scilla*	,,	5	5
	Iris	,,	5	5
	Lilium	,,	5	5

The first three lines of Table 2 show that the fungus was unable to enter an unwounded bulb but that wounded bulbs were readily attacked. Wounded bulbs of *Scilla campanulata* were also attacked. This is in accordance with the results of Macfarlane (1939) who obtained no infection of unwounded bulbs even when these were kept under moist, warm conditions.

A comparison was made between *Penicillium cyclopium* isolated from bluebells and of *P. cyclopium* and *P. corymbiferum* isolated from rotted iris (bulbous *Iris* var. Wedgewood) and lily bulbs (*Lilium regale*) respectively.

Scilla, *Iris* and *Lilium* bulbs were wound-inoculated with the three strains of *Penicillium* and the results are shown in Table 2. All the controls remained sound.

Thus all three strains could attack all three hosts when introduced into wounds. No difference in degree of virulence could be detected. No positive results were obtained with unwounded bulbs.

VI. Control measures

Table 1 shows that slightly infected bulbs are able to grow, produce flowers and to increase in weight when planted in a light, well-drained soil. Thus in such a soil a stock should give satisfactory results if all bulbs showing severe rotting are discarded before planting.

Field observations suggest, however, that the disease becomes more severe in comparatively wet soils and that the attack by *Penicillium* may even be the factor limiting the establishment of bluebells in wet areas of woods or gardens. A stock of clean to slightly diseased bulbs of *Scilla nutans* was planted in the autumn in light, well-drained soil and in a heavier, poorly drained soil. Growth and flowering were good in both lots but when the bulbs were lifted in July, 448 bulbs out of 2200 (i.e. 20·4 %) grown in the heavy soil were severely diseased while there were only sixty-four severely diseased bulbs out of 2400 (i.e. 2·7 %) grown in the light soil.

A small scale experiment under more controlled conditions was also carried out in which clean or slightly diseased bulbs were planted

Table 3

Treatment	No. of bulbs used.	No. clean.	No. slightly diseased. *Penicillium*	No. severely rotted. *Penicillium*	No. completely rotted.
Dry	100	84	15	1	0
Wet	100	41	22	29	8

in autoclaved soil in small tins. Half of the bulbs were watered freely and half sparingly. The water content was kept fairly constant during the experiment by weighing the tins and adding water to bring them up to this weight at frequent intervals. The results of this experiment which are given in Table 3 show that the number of diseased bulbs and the severity of the disease were much greater in those grown in wet soil. Thus thirty-seven of these were so badly diseased as to be useless for planting while only one of those from the batches kept relatively dry was severely diseased.

A parallel series in which the bulbs were steeped for three hours in a 0·5 % solution of a proprietary organic mercurial fungicide gave similar results and no significant reduction in the amount of disease was obtained.

Replicated field experiments involving 4000 bulbs were carried out over two growing seasons in which bulbs were treated with a variety of fungicides (viz. formalin, mercuric chloride, cuprous oxide, certain proprietary organic mercurial fungicides, bleaching powder and certain non-mercuric organic fungicides of the nitrobenzene type) before planting. The majority of the bulbs were clean or had small lesions only, but experiments were also carried out with more severely

diseased bulbs. Some were planted in light soil and others in heavy soil. Under none of these conditions were there any beneficial effects of fungicidal treatment either on the amount of disease present or on the increase in weight of the bulbs during the growing season. Thus disease control can be best effected by discarding all severely diseased bulbs and planting the remainder in a well-drained situation.

It might, however, be possible to treat bulbs when lifted in such a way that they would remain sound when stored for sale or transport. An experiment was carried out in which bulbs were treated with a variety of fungicides when lifted in August. Both treated and untreated lots remained sound under conditions of good ventilation during August and September but the amount of disease was greatly increased under conditions of high temperature and humidity. Macfarlane (1939) was unable to obtain infection of wounded bulbs when these were kept dry while similar bulbs kept under moist conditions were all attacked. This attack was most rapid at relatively high temperatures. A small scale experiment also indicated that early planting of bulbs was advantageous. Thus when it is necessary to store bulbs for sale, a minimum period of storage under cool, well-ventilated conditions is likely to reduce losses.

VII. Summary

1. A strain of *Penicillium cyclopium* Westling was isolated from rotted bulbs of *Scilla nutans*. The symptoms are described in detail and a description of the fungus is given.

2. Inoculation experiments gave definite results, viz. that *Penicillium cyclopium* would penetrate only when bulbs were wounded. Strains of *Penicillium* isolated from *Lilium* and *Iris* bulbs could infect the wounded *Scilla* bulbs and, conversely, *Penicillium cyclopium* from *Scilla* was pathogenic to wounded *Lilium* and *Iris* bulbs.

3. In field experiments, various fungicides were used as dusts or in solutions to control the disease, but the results obtained were not conclusive. Both in the field and in greenhouse experiments the amount of disease was greater in wet soil.

4. Small scale experiments indicated that the amount of disease was greatly increased if bulbs were stored under conditions of high temperature and humidity.

Thanks are due to Dr L. E. Hawker for suggesting this investigation, for direction during its progress and for assistance in the preparation of the manuscript.

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NEW METHODS FOR THE CULTIVATION OF WOOD-ROTTING FUNGI

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(With Plates VII and VIII)

Tests were started in 1937 with the object of finding a medium on which wood-destroying fungi would make more vigorous growth and on which they would fructify more readily than they do on malt agar. For these purposes experiments were carried out with a mixture which had been found in practice to stimulate the growth of mushroom spawn causing the mycelium to 'run' vigorously. This mixture, which is referred to below as the 'accelerator', was composed of the following ingredients:

Maize meal	50	parts	by weight
Bone meal (containing 3·75 % organic nitrogen)	30	,,	,,
Potato starch	17	,,	,,
Sucrose	2	,,	,,
Wood ash (from combustion of Scots pine sap-wood)	1	,,	,,

Preliminary tests using 1 and 5 % by weight of the mixture in 2 % malt agar showed that it has a marked stimulating effect on the growth of wood-rotting fungi in culture. Vigorous growth developed in cultures of several fungi which had previously made only very feeble growth on the malt agar alone. The medium containing 5 % accelerator supported more vigorous growth than that with 1 %. Experiments were then carried out adding the accelerator to sawdust instead of agar medium. Sawdust alone is not a satisfactory medium for the cultivation of most Basidiomycetes, and many wood-rotting fungi make surprisingly poor growth on it. It was felt, however, that if the mycelium could be induced to 'run' through the sawdust and develop vigorously, fructifications might be more readily produced on a sawdust medium than on agar, since the aeration of the medium is so much better, and the total amount of nutrient material greater. In sawdust a moisture content of 170 % (based on the oven-dry weight) has been found to be satisfactory for most fungi, although considerably higher moisture contents can be tolerated.

Dry sawdust—beech or spruce—was *thoroughly* mixed with 5 % of the accelerator and brought to the required moisture content with tap water. Petri dishes were filled with the mixture and autoclaved for 20 min. at one atmosphere pressure. Control plates containing sawdust alone were also prepared. After sterilization the plates were inoculated with the twenty species of fungi listed below. When inoculating sawdust with small pieces from an agar culture it was found that the fungus developed better if the transplant were laid gently on the surface of the sawdust and not buried or covered with particles of it.

All the fungi produced exceptionally rapid and luxuriant growth on the sawdust containing the accelerator, the growth on the sawdust alone always being decidedly inferior to that on the treated sawdust. With certain species, e.g. *Lentinus cochleatus*, the growth on the control plates was negligible. Of the twenty species tested, eight formed fruit bodies on the sawdust with the mixture, while none fruited on a control plate. It is worthy of note that the strain of *Polystictus versicolor* used in these tests had never previously fructified on agar medium or wood blocks during the fourteen years it had been in culture in the Laboratory, during which time many hundreds of subcultures of it had been made.

Fungi used in Petri dish tests with treated sawdust

Beech sawdust		Norway spruce sawdust	
Fungus	Fructification, etc.	Fungus	Fructification, etc.
Armillaria mellea	(Rhizomorphs)	*Lentinus lepideus*	—
Collybia fusipes	—	*Lenzites trabea*	Formed
Collybia velutipes	—	*Merulius himantioides*	—
Fomes annosus	—	*M. lacrymans*	—
Lentinus cochleatus	Formed	*Poria Vaillantii*	Formed
L. tigrinus	—	*P. vaporaria*	Formed
Merulius serpens	—	*P. xantha*	Formed
Phellinus cryptarum	Formed	*Stereum sanguinolentum*	—
Polyporus umbellatus	—	*Trametes serialis*	Formed
Polystictus versicolor	Formed		
Fungus 344 from Palestine	Sclerotia formed for first time in culture		

N.B. Except in *Phellinus cryptarum*, all the fructifications which were formed bore normal basidiospores.

In order to discover the relative importance of the different ingredients in the accelerator a test was carried out to determine the loss in weight of samples of sawdust to which (1) maize meal, (2) bone meal, (3) wood ash, (4) starch, (5) the complete mixture, had been added. Samples of untreated sawdust were also included as controls.

The treated and control samples of sawdust were placed in weighed 100 c.c. conical flasks, oven-dried, reweighed and brought to 250 %

moisture content with distilled water. The flasks after being plugged with cotton-wool were autoclaved for half an hour at one atmosphere, inoculated with *Merulius lacrymans* and incubated at 22° C. for four months. The sawdust was then oven-dried and the loss in weight determined and expressed as a percentage of the original dry weight.

Results

Medium	Loss in dry weight % after 4 months
Sawdust only (controls)	1·9
Sawdust + 2·5 % maize meal	49·2
„ + 1·7 % bone meal	41·0
„ + 0·05 % ash	3·5
„ + 1·0 % potato starch	1·1
„ + 5·0 % complete accelerator	54·0

The differences in the losses in weight which were sustained are very striking, and it may be noted that similar differences in the mycelial development could be observed. It is evident that both the maize and the bone meal have a pronounced stimulating effect on the growths of the fungi, and it is hoped at a later date to investigate the relative importance of these ingredients and the physiological explanation of their effect on the growth of fungi. It was noticeable that the growth and loss in weight brought about by *Merulius* was much more uniform between one flask and another in the sawdust containing maize or bone meal, or the complete accelerator, than it was in the untreated sawdust. The use of the treated sawdust as a medium for cultivating the test fungi to be used in laboratory tests of the natural resistance to decay was, therefore, suggested.

When it is desired to carry out comparative tests on the resistance to decay of species of timber which are naturally highly resistant to attack, and which contain substances toxic to fungi, it is frequently difficult to get any growth from cultures on malt agar, as the toxic substances present in the wood may kill off the superficial mycelium. Trials were made, therefore, with cultures grown on the sawdust mixture after pilot tests with malt agar had proved unsatisfactory when testing western red cedar (*Thuya plicata*).

In a comprehensive test on the variations in resistance to decay in the different parts of a log of home-grown western red cedar, a wide range of fungi was grown on the sawdust medium in culture flasks. All the samples were supported above the fungus on glass rests. The species used are listed below, together with observations on the extent of decay in the cedar samples.

All the twenty-five species tested grew luxuriantly on the sawdust containing the accelerator, and the growth was always much more vigorous than that on plain sawdust (Plate VII, fig. 1). *Fomes roseus*,

F. Demidoffii, *Polyporus Berkeleyi* and *Trametes Pini* made no visible growth at all on the sawdust alone. Only four fungi—*Phellinus cryptarum*, *Polystictus versicolor*, *Poria subacida* and *P. Weirii*—grown on plain sawdust attacked the cedar samples, and in each, growth took place several weeks later than in the flasks with the accelerator. With certain fungi, e.g. *Fomes geotropus*, the growth from the sawdust with the accelerator on to the cedar was rapid (Plate VII, fig. 2).

This sawdust medium thus appears to be particularly suitable for the cultivation of fungi to be used for tests on the resistance to decay of naturally durable timbers, and it has also been found to be a very useful medium on which to cultivate the test fungi used in the laboratory testing of wood preservatives. The medium should also prove useful for the maintenance of standard culture collections of wood-rotting species, as fungi grown on it would not require such frequent subculturing as when grown on agar.

Condition of Thuya plicata *samples after* 9 *months in culture*

(Medium: sawdust plus accelerator)

Fungus	Remarks
Coniophora cerebella (Liese's strain)	Good growth. Many samples. Badly decayed. Av. loss in wt. 21·1 %
Echinodontium tinctorium	No growth
Fomes geotropus	Excellent growth. Slightly decayed
F. Demidoffii	No growth
F. pinicola (98 A)*	Slight growth at base. No attack
F. roseus (140 A)*	No growth
Lentinus lepideus (Liese's strain)	Very slight growth at base. No attack
Phellinus cryptarum	Excellent growth. Slightly decayed
Polyporus anceps	Moderate growth. Springwood decayed
P. balsameus	Excellent growth. Some attack
P. Berkeleyi	Very slight growth at base. No attack
P. borealis (Mounce's strain)	Very slight growth at base. No attack
P. guttulatus	Good growth. Slight to moderate decay
P. mollis	No growth
P. rugulosus (ex S. African mines)	Excellent growth. Moderately decayed
P. tephroleucus	Moderate growth. Badly decayed at base
Polystictus versicolor (F.P.R.L. strain)	Good growth. Many samples badly decayed
Poria incrassata	Excellent growth. Many samples badly decayed
P. subacida (Richard's strain)	Good growth. Slight decay in some samples. Av. loss in weight 3·5 %
P. vaporaria (Liese's strain)	Moderate growth. On average rotted at base
P. Weirii (Bur. Pl. Ind. Washington)	Excellent growth. Samples moderately decayed. White pockets. Av. loss in weight 12·9 %
Poria xantha	Excellent growth. Very slight attack
Trametes Pini (45 B)*	Slight growth. No attack
T. serialis (107 B)*	No growth, nor loss in weight
T. subrosea (106)*	Slight growth. No attack

N.B. Norway spruce sawdust was used in all the cultures except those of *Polystictus versicolor* for which beech dust was used.

The amount of accelerator added to the sawdust may vary within wide limits, and yet vigorous growth can still be obtained. As little as 1 %, if well mixed with the sawdust, has a pronounced effect on

* Reference numbers in F.P.R.L. collection.

most fungi—on the other hand, when exceptionally vigorous growth is required, up to 10 % may be used, but in general 5 % will be found to be about the optimum.

A preliminary test was carried out to ascertain the effect of adding the accelerator to soil. Samples of dark virgin loam were thoroughly mixed with 20 % by weight of the mixture, brought to a moisture content of 170 %, and after sterilization were infected with *Merulius lacrymans* and *Coniophora cerebella*. Both fungi grew rapidly on the soil plus accelerator, but made no appreciable growth on the control flasks containing soil only (Plate VIII, fig. 1). Samples of *Thuya plicata* (supported on glass rests), which were introduced into the flasks containing the soil plus mixture, were completely covered with mycelium in about ten days (Plate VIII, fig. 2).

Further comparative tests are necessary before it can be decided whether soil plus accelerator is better or indeed as good as sawdust with it. Soil has been used by a number of investigators as a medium for infecting test samples impregnated with wood preservatives, and it is suggested that the addition of a certain percentage of the accelerator described above would render the soil a much more suitable medium than soil alone, for the cultivation of the wood-rotting Basidiomycetes, which are used in laboratory tests on the toxicity of antiseptics.

It was found that it is possible to produce quick and luxuriant mycelial growth of certain wood-rotting fungi on absorbent cotton-wool by the following method: Pledgets of absorbent cotton-wool are soaked in distilled water until they contain about seven times their weight of liquid. These are then sprinkled lightly with the accelerator and piled in boiling tubes (4 cm. in diameter), leaving a space of 0·25 cm. between each pledget. The tubes are then autoclaved for half an hour at one atmosphere. An inoculum is placed on the top pledget in each tube.

The following fungi have been grown on cotton-wool plus accelerator: *Armillaria mellea*, *Coniophora cerebella*, *Fomes Laricis*, *Lentinus lepideus*, *Merulius lacrymans*, Palestine Fungus No. 344, *Phellinus cryptarum*, *Polyporus benzoinus*, *P. Schweinitzii*, and *Trametes serialis*.

All these fungi, with the exception of *Armillaria mellea*, made rapid growth on this medium. At 22° C. most of them had grown in three weeks to the bottom of the pile of wool—a depth of 16 cm. At the end of four months the wool was removed from these cultures and found to be decayed in all but those inoculated with *A. mellea*.

By this cotton-wool method inocula can be prepared quickly for infecting timber in an experimental floor, mine, toxicity chamber or living tree, its main advantage being that the inocula, unlike masses of sawdust or pieces of agar, can be nailed or tied in almost any position, and should remain moist long enough to enable the fungus

Fig. 2

NORWAY SPRUCE SAWDUST
MOISTURE CONTENT 110%
AGE OF CULTURES - 3 WEEKS.
+10% MANURE
CONTROLS
PORIA WEIRII
FOMES CRYPTARUM
PORIA SUBACIDA

Fig. 1

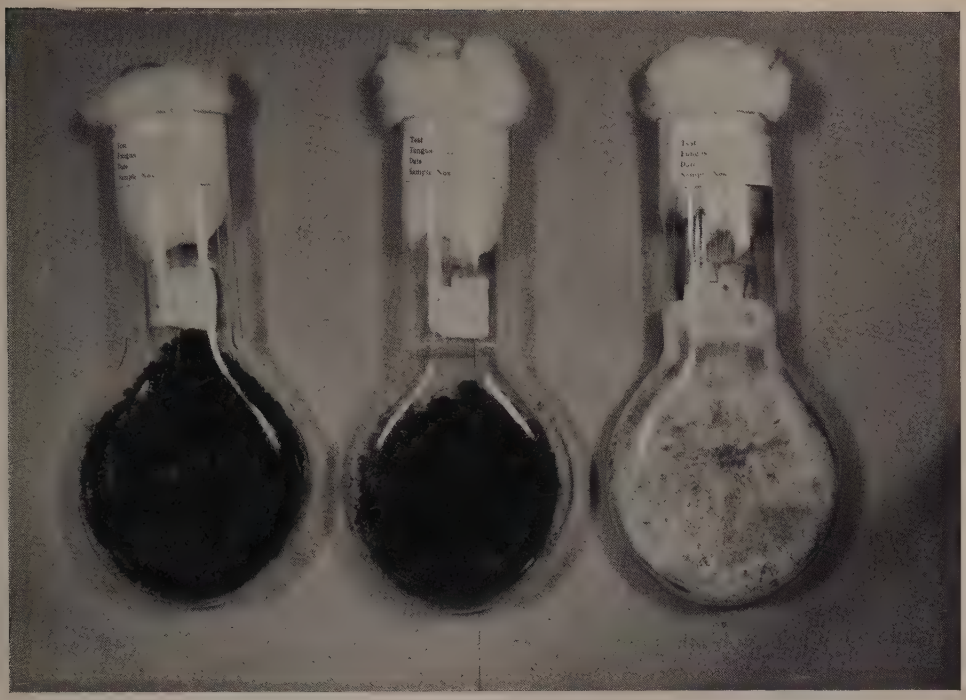

Fig. 1

Fig. 2

to grow on to the test material. On account of their high water-absorbing capacity, the inocula can be watered if necessary. This would be particularly useful under conditions where inocula become dry before the fungus can develop on the test timber.

Summary

A new medium for the cultivation of wood-rotting fungi is described. This consists of sawdust of a readily decayed species of wood such as beech or spruce, well mixed with 5 % by weight of an accelerator, the principal ingredients of which are maize meal and bone meal. On this medium exceptionally vigorous growth of a wide range of species has been obtained. The use of this medium for laboratory tests on the resistance to decay of naturally durable timbers or of samples impregnated with wood preservatives is suggested. The addition of the accelerator to garden soil or to cotton-wool also makes a medium on which very vigorous growth can develop.

The work described in this report was undertaken as part of the programme of the Forest Products Research Board, and is published by permission of the Department of Scientific and Industrial Research.

EXPLANATION OF PLATES VII AND VIII

Plate VII

Fig. 1. Cultures on sawdust media ready for inoculation of *Thuya plicata* samples.

Fig. 2. Home-grown *Thuya plicata* samples inoculated with *Fomes geotropus*. Medium: sawdust of Norway spruce (on left) + accelerator (on right) sawdust control. 8 days after introduction of samples.

Plate VIII

Fig. 1. Soil inoculated with *Merulius lacrymans*. Flask on right contains soil + accelerator, left and centre—soil only. Age of cultures 18 days.

Fig. 2. *Merulius lacrymans* on soil + accelerator. Two samples of *Thuya plicata* (home grown) 6 weeks after inoculation. The growth on to the wood takes place immediately, the samples being covered in 10 days.

(*Accepted for publication* 1 *June* 1941)

NEW AND INTERESTING PLANT DISEASES

By W. C. MOORE
Plant Pathological Laboratory, Harpenden

(With Plate IX)

10. A leaf blotch of *Cypripedium* caused by *Penicillium thomii* Maire

On passing through a commercial orchid nursery one cannot fail to notice the astonishing variety of spotting and blotching that occurs on the leaves of most plants old enough to flower. Articles on 'Spot' in orchids have appeared from time to time for many years in the horticultural press and elsewhere, but it is still true to say, as Berkeley (1865) did three-quarters of a century ago, that 'every gardener complains of the spot in Orchids, but no one seems to know how to prevent it, and few are agreed as to the cause'. The subject has been given little attention in this country since Brierley (1919) distinguished seven distinct forms of spot or blotch on various species of orchid. Three of these were attributed to non-parasitic causes and four to parasites.

Towards the end of May 1941 Mr E. Skillman, of the Ministry of Agriculture, brought me a few leaves of *Cypripedium callosum* which showed blotches of a type I had not previously seen. On visiting the nursery in Hertfordshire from which the specimens had been received, it was found that one or more of the older leaves on about half of several hundred plants showed similar blotching, and single blotches were also present on some of the younger leaves. A second batch of *C. callosum* obtained from another source was practically free from the trouble. The blotches were up to $1\frac{1}{2}$ in. across, rounded or elongated, relatively watery and uniformly deep brown, though frequently with a pale brown margin $\frac{1}{8}$ in. wide, surrounded by a water-soaked 'halo' about $\frac{1}{8}$ in. wide. Some were situated near the middle of the leaf and others were spreading inwards from the leaf edges (Pl. IX, fig. 1), while occasionally the whole of the stalk end of one or more of the oldest leaves was affected. Smaller, irregular, brown spots without the halo were also observed; these were harder in texture, and with the surface wrinkled as though the infection had been checked, and the spots were drying out. On most of the spots or blotches there was no visible fungal growth, but on a few there was a fine blackish incrustation consisting of the mycelium and

spores of a *Cladosporium* indistinguishable from *C. herbarum* (Link) Fr. Later, when a special search was made, conidiophores of *Penicillium* were also found, but only on one or two of the larger blotches.

Petri dish cultures made from the pale brown margin of several of the larger blotches and from the tissues in the water-soaked area, yielded *Cladosporium herbarum*, a sclerotia-forming *Penicillium*, and two kinds of bacterial colonies, one pink and one white. The *Penicillium* was isolated only from the water-soaked region, the others from both areas. All four organisms were obtained in pure culture and preliminary inoculation experiments were carried out with each one, through wounded leaves on a plant of *Cypripedium callosum* kept under a bell-jar at room temperatures. Negative results were obtained with the bacteria and with *Cladosporium herbarum*, but blotches up to $\frac{3}{8}$ in. across were produced within three days by the *Penicillium*. This was successfully re-isolated a week later, when the blotches were up to $\frac{3}{4}$ in. in diameter.

It may be recalled here that a species of *Cladosporium*, originally named *C. orchidearum* Cooke & Mass. (Cooke, 1888), was at one time regarded as the cause of a leaf and bulb disease of orchids (Smith, 1890), but Massee (1910), who erroneously cited the fungus as *C.* '*orchidis* (Cke. & Mass.)', was unable to infect the leaves of *Cattleya* and other orchids with it. On the other hand, Brierley (1919) attributed an olive-green blotching of different species of orchid to a species of *Cladosporium* that did not appear to differ from *C. herbarum* (Link) Fr.

On 14 June 1941 further inoculations were carried out with the *Penicillium* on plants of *Cypripedium callosum* kept reasonably isolated in one of the orchid houses on the nursery. Pieces from pure cultures of the fungus were placed on the wounded or unwounded upper surface of leaves of different ages. When examined nine days later none of the eighteen inoculations of unwounded tissues had taken, but every one of the eighteen inoculations made through small cuts in the leaf had given positive infection. Other leaves, that had been wounded but not inoculated, were still healthy. The spots or blotches produced on the wounded leaves were from $\frac{1}{2}$ to $1\frac{1}{2}$ in. across and closely resembled those occurring on naturally infected plants. On the whole the smaller spots occurred on the younger leaves and the largest ones on the older leaves. Some spots had apparently ceased to be active, while others (Pl. IX, fig. 2) showed the pale brown margin and water-soaked halo observed on naturally infected leaves. The *Penicillium* used for the inoculations was re-isolated without difficulty from eight of the spots.

A smaller number of inoculations was made on the leaves of *Cypripedium insigne Sanderae*, but this species proved much more resistant. No infection occurred through unwounded tissues and five

of the ten inoculations made through cuts gave a negative result. In the others slight infection occurred, but none of the spots produced was more than $\frac{1}{4}$ in. in diameter after nine days.

A pure culture of the *Penicillium* was sent to Mr George Smith at the London School of Hygiene and Tropical Medicine, and he very kindly examined it and identified it as a strain of *P. Thomii* Maire, which shows the spreading habit and the numerous pink sclerotia characteristic of the species, and differs only in minor details from Maire's description. I am very grateful to Mr Smith for the following diagnosis of this strain:

Cultures on Czapek agar predominantly sclerotial, with irregular conidial areas pale green, becoming pale grey-green; reverse dull yellow with patches of deeper yellow to dull orange. On wort agar young cultures predominantly conidial, greyish blue-green, turning darker and duller, velvety, with clusters of sclerotia developing gradually from centre outwards. Penicilli monoverticillate: conidiophores unbranched, smooth, 2·5–2·8 μ diam.; sterigmata abruptly pointed, 8–11 μ by about 2 μ; conidia subglobose, smooth, 2·5–3 μ in long axis; conidial chains in loose columns; sclerotia very pale dull pink, roughly globose, often confluent, up to about 200 μ in diameter.

The origin of the fungus is unknown, though it was probably imported with the plants some years ago. In the past *P. Thomii* Maire has been found on a variety of substrata. It was first named from a specimen on *Amanita ovoidea* in Algeria and has been observed growing saprophytically on mushroom and chestnut in the United States of America (Thom, 1930). A few years ago it was reported impairing the quality of stored butter in Germany, and in that country, as well as in Austria and England, it has been isolated from soil.

There appears to be no previous record of *P. Thomii* behaving as a parasite but it is considered to be the cause of the particular form of 'spot' or blotch described above, and as such it is the only species of the genus reported to be pathogenic to orchids. Infection takes place only through wounds, to which orchid leaves are particularly liable on account of their brittleness. Young leaves are less susceptible than older ones.

11. Leaf spot of *Primula*

In view of the proof recently advanced by Gregory (1939) that *Ramularia vallisumbrosae* produces amerospores, phragmospores and scolecospores, corresponding respectively to the genera *Ovularia*, *Ramularia* and *Cercosporella*, attention may be drawn to what will probably prove to be similar behaviour in *Ramularia Primulae* Thüm., the cause of Leaf Spot of Primulas. *R. Primulae* was regarded as new

to Britain when Massee (1891) found it on *Primula rosea* in Shropshire. Nowadays it is often found on wild primroses and sometimes also on cultivated forms. It is more conspicuous in wet than in dry seasons, but rarely causes serious damage.

Some years before Massee's record, Berkeley and Broome (1875) had described *Peronospora interstitialis* B. & Br. on primrose in Scotland. The fungus was not a phycomycete and was later transferred by Massee (1893) to *Ovularia* as *O. interstitialis* (B. & Br.) Mass., but Grove (1912) strongly suspected it to be merely a young condition of *O. primulana* Karst., which in turn he regarded as an immature stage of *Ramularia Primulae* Thüm. By suitable choice of specimens he was able to find all stages between the two extremes.

In May 1936 I examined some diseased seedlings of a *Primula Juliae* hybrid grown near Southampton. The leaves exhibited the yellow-brown or brown leaf spots commonly attributed to *Ramularia Primulae*, but the only fungus present on them proved to be a species of *Cercosporella*. It was identified as *C. Primulae* Allesch., previously reported in various parts of Europe on *Primula officinalis*, *elatior* and *acaulis* (*Rab. Krypt. Fl.* 1, 8, 1907, 425). Some of the seedlings of the *P. Juliae* hybrid were also attacked by *Peronospora Oerteliana* Kühn, and, acting on the advice given, the grower lifted all the plants from the affected beds, discarded those with pale or spotted foliage, and divided and replanted the remainder. Late in July, after an un usually wet summer, the same grower reported that *Cercosporella Primulae* had turned up again. He sent further specimens bearing spots indistinguishable macroscopically from those on the earlier material, but *Ramularia Primulae* was the only fungus present on them. Unfortunately, no cultures were made from the first material received and I have not again found the *Cercosporella*, but it seems highly probable that the two fungi are related genetically.

12. Leaf spot of *Helenium* (*Septoria Helenii* Ell. & Everh.)

At the beginning of July 1941 leaf spots appeared on two clumps of *Helenium* 'Moerheim Beauty' just coming into flower bud in my garden. Two other clumps only a few feet away were unaffected at the time but showed similar spotting within a fortnight. The spots, which caused no appreciable damage, were $\frac{1}{2}$–2 cm. in diameter, amphigenous, scattered or spreading from the leaf edges, and sometimes coalescing. They were greenish brown, tan or chocolate-brown, paling later, rounded, sharply defined, often with a narrow, deeper coloured margin about $\frac{1}{2}$ mm. broad, and occurred mainly on the lower leaves, with occasional spots on the stem leaves a foot or more above soil level. After a time the spots sometimes spread beyond the original margins. Ultimately some of the affected leaves

withered in part or altogether, though the outline of the original spots was usually still visible (Pl. IX, fig. 3).

Pycnidia of a species of *Septoria*, identified as *S. Helenii* Ell. & Everh., were scattered uniformly over the spots as minute blackish dots, barely visible to the naked eye. They were few or many, epiphyllous, at first immersed, then erumpent, individually pale brown with a thin parenchymatous wall, somewhat thickened and darker around an ill-defined ostiole, more or less spherical, 66–112 μ in diameter, the majority about 90 μ. The spores were straight or curved, slightly pointed at the ends, hyaline, 0–4-septate and measured 22–39 × 2–3 μ (average length of 50 spores was 29·7 μ).

S. Helenii Ell. & Everh. appears to be the only species of the genus occurring on *Helenium*. It was collected on *H. autumnale* L. in Wisconsin by J. J. Davis in 1887 (Sacc. *Syll.* x, 369). In 1891 *Septoria nubilosa* Ell. & Everh. (Sacc. *Syll.* x, 369) was described from material on the same host, also collected by Davis in Wisconsin, but later Davis (1915) himself concluded that this was merely a form of *S. Helenii* in which the spots were not well developed. He found both forms on the same plant. *S. Helenii* has also been recorded from North America on *Helenium Hoopesii* Gray (Sacc. *Syll.* XIII, 551).

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EXPLANATION OF PLATE IX

Fig. 1. Leaf of *Cypripedium callosum* naturally infected by *Penicillium Thomii* Maire.

Fig. 2. Another leaf artificially infected by *P. Thomii*. Inoculated 14 June 1941. Photographed 23 June.

Fig. 3. Leaves of *Helenium* 'Moerheim Beauty' attacked by *Septoria Helenii* Ell. & Everh.

(*Accepted for publication* 20 *July* 1941)

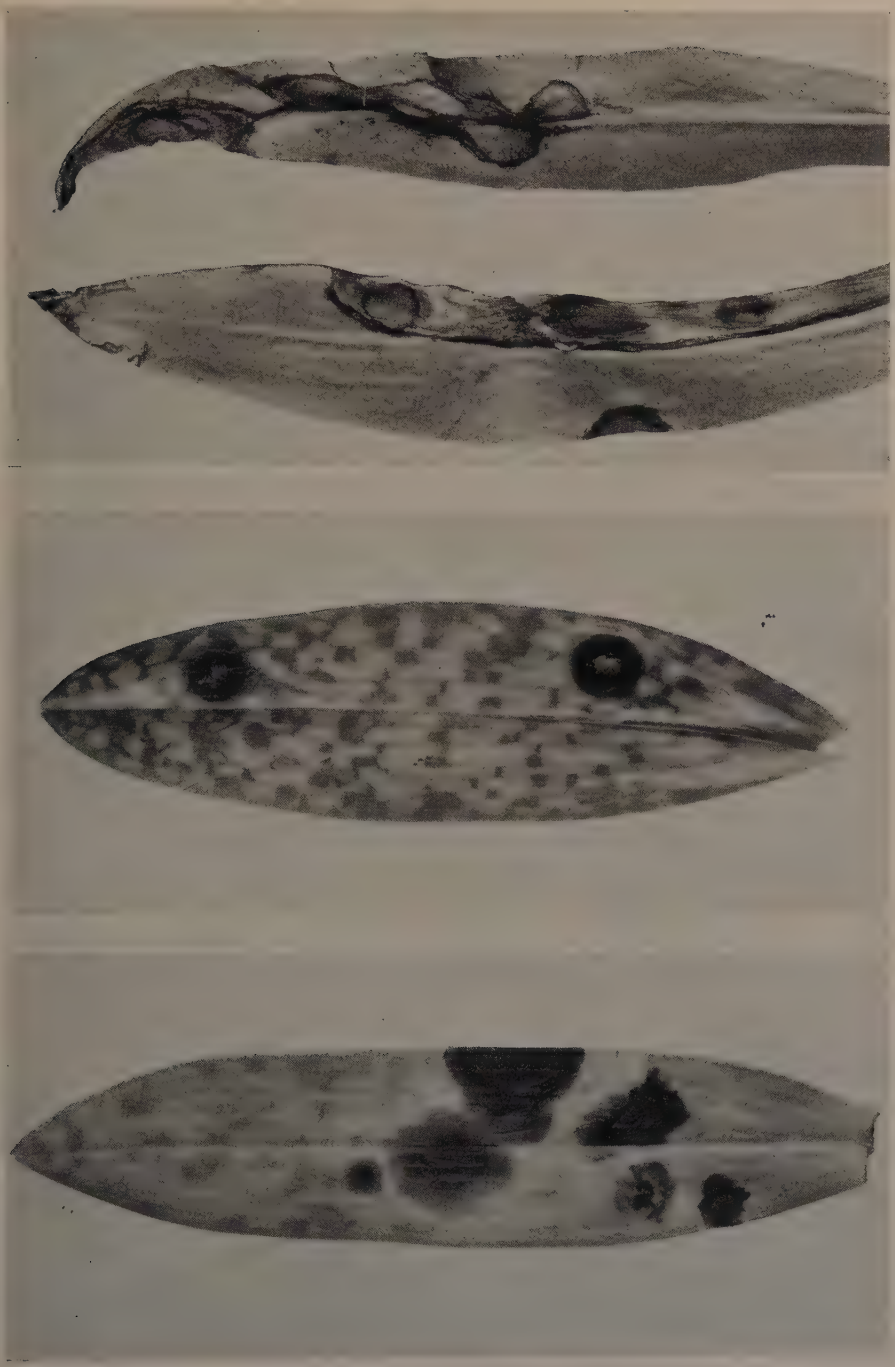

Fig. 3

Fig. 2

Fig. 1

Photographs by W. F. Buck

INSTRUCTIONS FOR PREPARING 'COPY', SETTING TYPE AND READING PROOFS

CORRESPONDENCE between the editors of the *Transactions* and the Cambridge University Press has led to the preparation of a set of instructions for the guidance of the Press in producing the *Transactions*. These instructions are printed below, for the information of those intending to submit material for publication in the *Transactions*.

Contributors are asked to follow these instructions when they prepare their manuscripts; by so doing they will save the editors and printers much unnecessary mechanical work, and, by reducing the amount of correction to be done, they will help to reduce the cost of producing the *Transactions*.

(1) Spellings to follow *A New English Dictionary* (*Oxford Dictionary*).

(2) *Dates*. In text use: 21 March 1941. In tables: 21. iii. 41.

(3) Chemical symbols, printed in roman type, may be used in tabular matter for convenience of space. In the text, symbols must not be used, the name of the element or compound being put out in full: e.g. nitrogen, *not* N; ferrous sulphate, *not* $FeSO_4$.

(4) Use figures for all dimensions, weights, distances, etc., e.g. 4 kg., 5 in., 2·5 m., 3 cm., except where the style clearly demands the use of words, e.g. 'two miles from Cambridge'. In reading matter spell out numbers of less than three figures: e.g. ninety-nine, twelve; but 101, 238. If numbers are in groups, use figures, e.g. 12, 208, 32, 41.

Avoid figures as numbers at beginning of sentence. Use 'half a mile' *not* '$\frac{1}{2}$ mile', and 'one-fifth' *not* '$\frac{1}{5}$' or '1/5', when fractions stand alone.

Give time of day as 4 a.m., 6 p.m., but use 'four o'clock' *not* '4 o'clock'.

(5) Contract collective numbers: e.g. 1921–4, 1938–41, 1903–4, 1911–12; *but* from 1914 to 1920, *not* from 1914–20.

(6) *Botanical terms, etc.* Names of genera and species should be italicized. The specific epithet may begin with a capital or with a lower-case letter; always follow copy.

Anglicized words derived from Latin names of groups should begin with a lower-case letter: e.g. Gymnospermae, gymnosperms; Coniferae, conifers.

When the name of an author follows the botanical name no punctuation should be inserted between that name and the authority, but a comma should be inserted between the authority and the date which follows it, if there is a date. Names of authors are sometimes

placed in parentheses, and copy should always be followed, e.g. *Pluteus* Fr.; *Pluteus gracilis* (Bres.) Lange, 1924.

When there are collaborating authorities, their names, or the usual abbreviations for those names, will be linked by ampersand (&), and *not* by and, et, or any other form, e.g. *Corticium Solani* Bourd. & Galz.

(7) Use n.gen., n.sp. *not* nov.gen., nov.sp. or the many variants. Use the form gen.nov., sp.nov. with Latin diagnoses.

(8) Reduce hyphenated words to a minimum, but the general rules set out in *Rules for Compositors & Readers at the University Press, Oxford*, 1936, pp. 33–7 are to be followed.

(9) The decimal point must always be preceded by a figure, e.g. 1·234, 0·123.

(10) Reference to plate numbers is made by roman numerals, e.g. Pl. III; to Figs. and Tables by arabic numbers, e.g. Fig. 2 or Text-fig. 2, and Table 2.

(11) *References.* References in text and in alphabetical list at end of article are governed by the following rules:

(i) *In text.* References are denoted by giving name of author followed by date of publication from which citation is made, e.g. (Brown, 1941). Collaborating authors are joined by an ampersand when reference is parenthetical, but 'and' must be used in running text: e.g. 'Smith and Brown (1941) have shown...'; 'Some authors (e.g. Smith & Brown, 1941) have shown...'. Where three or more authors have collaborated full names should be given at first citation and after that *et al.* should be used with first name only: e.g. (Smith, Jones & Robinson, 1941) at first, then (Smith *et al.* 1941) afterwards.

(ii) *Alphabetical list at end of article.*

(*a*) Author's name, followed by initials. Collaborating authors should be joined by &.

(*b*) Date of publication in parentheses. Where an author has published two or more papers or books in any one year, *a*, *b*, *c*, etc., should be added to date and inside parentheses, both here and in text.

(*c*) Title of paper or article in full and in roman type without quotation marks. If translated from a foreign language crotchets should be inserted at beginning and end of title.

(*d*) Name of periodical or journal from which article is cited, and printed in italics. Titles of journals to be abbreviated in accordance with editor's marking; the *World List* will not always be followed. All titles of periodicals must be repeated, the use of ibid. not being allowed.

(*e*) The name of a book which is cited, printed in italic, followed by edition number.

(*f*) Volume number in roman numerals and in roman type, followed by complete page numbers of article. Where no volume number is given print p., no. or part, in ordinary type.

The following shows complete references:

BROWN, A. B. (1941). The nature of fungi. *Proc. Roy. Soc.* B, CXX, 19–25.

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(12) Words of foreign origin generally accepted as part of the English language, and well-known scientific terms, should be printed in roman type. Examples are: in situ, in vitro, bona fide, prima facie, résumé, role.

(13) *Capitalization.* Avoid capital initials as far as possible, but no hard and fast rules can be laid down about them. Names of diseases of plants, etc., must be left to the discretion of the editor.

(14) Single quotes ' ' should be used throughout, and only in a quotation within a quotation should double " " be used.

(15) The following is a list of contractions in general use. This list must be strictly adhered to, unless special instructions are given to the contrary; contractions will not be used in running text, except as provided for in Rule 4:

Absolute	abs.	Calculated	calc.
Acceleration	acc.	Calorie (small, gram-calorie)	cal.
Alternating current	a.c.	Candle-power	c.p.
Ångström units	A.	Centigrade	C.
Ante meridiem	a.m.	Centimetre	cm.
Approximate	*c.*, approx.	Centimetres per second	cm./sec.
Atmosphere	atm.	Coefficient	coeff.
Atomic weight	at. wt.	Concentration	conc.
Boiling-point	b.p.	Constant	const.

Cubic inch	cu. in.
Cubic foot	cu. ft.
Cubic yard	cu. yd.
Cubic millimetre	cu. mm.
Cubic centimetre	c.c.
Cubic metre	cu. m.
Cubic (except c.c.)	cu.
Decalitre	dl.
Decimetre	dm.
Dextrorotatory	*d*-
Direct current	d.c.
Drachm or dram	dr.
Fahrenheit	F.
Feet per second	ft./sec.
Feet per minute	ft./min.
Foot	ft.
Foot-candle	f.c.
Freezing-point	f.p.
Gallon	gal.
Grain	gr.
Gram	g.
Gram-molecule	g.mol.
Greenwich mean time	G.m.t.
Height	ht.
Horse-power	h.p.
Hour	hr.
Hundredweight	cwt.
Hydrogen-ion concentration (negative log of)	*p*H
Inch	in.
Iodine value	i.v.
Kilo-	k
Kilogram	kg.
Kilogram-calorie	kg. cal.
Kilolitre	kl.
Kilometre	km.
Kilowatt	kW.
Laevorotatory	*l*-
Latitude	lat.
Litre	l.
Longitude	long.
Low frequency	l.f.
Maximum	max.
Mega- or Meg-	M
Melting-point	m.p.
Metre	m.
Metre-candle	m.c.
Micromicron	$\mu\mu$
Micron	μ
Milli-	m
Milligram	mg.
Millilitre	ml.
Millimetre	mm.
Millisecond	msec.
Minimum	min.
Minute	min.
Molar	*M*
Molecular weight	mol. wt.
Mouse unit	m.u.
Normal	*N*
Ordnance datum	O.D.
Ordnance survey	O.S.
Ortho-	*o*-
Ounce	oz.
Page, pages	p., pp.
Para-	*p*-
Parts per million	p.p.m.
Pennyweight	dwt.
Per annum	p.a.
Per cent	%
Pint, part	pt.
Post meridiem	p.m.
Potential difference	p.d.
Pound	lb.
Quart	qt.
Rat unit	r.u.
Relative humidity	R.H.
Revolutions per minute	rev./min.
Second	sec.
Secondary	*sec.*-
Specific gravity	sp. gr.
Specific heat	sp. ht.
Square inch	sq. in.
Square foot	sq. ft.
Square yard	sq. yd.
Temperature	temp.
Tertiary	*tert.*-
Thermal death point	t.d.p.
Vapour density	v.d.
Vapour pressure	v.p.
Volt	V.
Watt	W.
Weight	wt.
Yard	yd.

PROCEEDINGS

PHYTOPATHOLOGICAL MEETING

Held on 17 April 1941, in the Lecture Theatre of the Botany School, Cambridge

The President, W. C. Moore, Esq., M.A., in the Chair

Prof. F. T. Brooks. Phytopathological observations in Australia and New Zealand, 1939.

(The author did not supply a summary.)

Dr R. E. Taylor. A Wilt disease of *Godetia* and other ornamental plants.

Fungi isolated from wilting plants of *Godetia* and Sweet Sultan in Cambridge were received from Prof. F. T. Brooks in 1938. These, together with other isolates obtained from *Godetia*, *Antirrhinum* and *Clarkia* were shown to be pathogenic to their respective hosts and to cause similar symptoms.

The typical symptoms as they appear in *Antirrhinum*, *Clarkia*, *Godetia* and Sweet Sultan are browning of the stem, principally in the lower parts of the plant, the extension of the lesion and final encirclement of the stem, followed by wilting. Pycnidia subsequently develop on the dead shoots.

One of the more interesting aspects of the investigation is the wide host range of each of the various isolates, and except for slight discrepancies the host ranges are comparable.

A careful cultural comparison of the isolates was made and although latterly this work was rendered difficult by the propensity of the fungi for altering in type, initially, however, the characters were almost uniform. Passage through different hosts did not appear to influence the cultural characters.

The mode of infection was investigated and consistently successful inoculations were obtained only when inoculation was accompanied by wounding. Infection was initiated through stems and leaves, and plants were conveniently infected in routine inoculation work by placing spore-suspensions on cut axillary shoots.

The fungi investigated belong to the Sphaeropsidales. The spores are hyaline, cylindrical with rounded ends, 6–9 $\mu \times 2{\cdot}5$–$3{\cdot}5\ \mu$ with 5–40% uni-septate; occasional spores are bi-septate. The characters are consistent with those of *Diplodina*. After careful comparison with material in the Kew Herbarium, the fungus from *Antirrhinum* is considered to be *Diplodina Passerinii* Allesch. Great similarity was observed in the appearance of the disease produced by the various isolates on different hosts, and in culture they do not differ sufficiently for them to be regarded as different species. The comparison strongly suggests that the fungi are separate strains of a single species, provisionally determined as *Diplodina Passerinii* Allesch.

Dr W. J. Dowson. Soft-rots due to green fluorescent bacteria.

Up to the present the majority of bacterial soft rots have been ascribed to what I here designate as *Bacterium carotovorum*, a member of a genus of non-sporing bacteria characterized by possessing paratrichous flagella and strong fermenting powers. A second species, *B. Aroideae*, attacks arum lily corms and hyacinth bulbs

in Britain but it has a much wider range of hosts in the United States and the tropics. *B. phytophthorum* causes the soft rot of potatoes known as Black Leg.

Quite recently a member of a different genus of bacteria was shown by Bonde in the United States to cause a soft rot of potato tubers in the ground, characterized by a yellowish colour as distinct from the white rot due to *B. carotovorum* or *B. phytophthorum*. Bonde did not identify this organism but stated that it was one of the 'green fluorescent' bacteria which are quite distinct from *Bacterium*. They possess a tuft of flagella situated at one end (polar or cephalotrichous), secrete the yellowish green pigment, fluorescin, into certain media, and exhibit but feeble fermenting powers. These 'green fluorescent' bacteria, which cause by far the greatest number of bacterial diseases of plants, constitute the genus *Pseudomonas* and one of them *P. marginalis* is responsible for a widespread disease of lettuce known as Marginal Spot prevalent here and in the United States. Under very humid conditions this Marginal Spot rapidly develops into a typical soft rot in which all the tissues, including the vascular system, are involved. So far *P. marginalis* is only known naturally to attack lettuce but its range of artificially inoculated hosts is considerable and is similar to that of the three species of *Bacterium* already mentioned. Onions, turnips, green tomatoes, cucumbers, green potato stems and potato tubers are quickly rotted and Bonde's 'green fluorescent' bacterium may well be this organism, as it produces a yellowish rot.

I recently investigated a rot of swedes characterized by extensive brown areas of softened tissue containing bacteria only. This rot was not nearly so soft or wet as is produced by *Bacterium carotovorum* etc. which could not be isolated from brown areas. A green fluorescent bacterium was isolated which under partially anaerobic conditions produced exactly the same kind of rot when introduced into turnips. It was at first suspected that this swede organism might be *P. marginalis*, but its biochemical reactions proved to be slightly different and it failed to produce a severe rot of lettuce.

A comparative set of tests of the pathogenesis of certain available pure cultures of species of *Pseudomonas* resulted in the identification of the swede organism with *P. Medicaginis* var. *phaseolicola*, the cause of Halo Blight of dwarf beans. Subsequent enquiry showed that to windward of the diseased swedes a crop of dwarf beans affected with Halo Blight had been grown the previous season and it would seem possible that some of the bean trash had been conveyed (by the wind) to the swedes. There seems no doubt that at least one soft rot disease is due to a species of *Pseudomonas*, and others are suspected, particularly certain types of potato tuber rots. This possibility should be borne in mind in considering control measures, for, whereas *Bacterium carotovorum* and other species of the genus *Bacterium* can gain entrance only through wounds, both *Pseudomonas marginalis* and *P. Medicaginis* var. *phaseolicola* are true parasites which enter their respective hosts through the stomata. The actual method of the swede infection is not at present known but is under investigation.

Dr S. Dickinson. Experiments on the physiology of obligate parasitism. II.

(The author did not supply a summary.)

Dr W. A. R. Dillon Weston. Field observations on some cereal diseases and their control.

The modern proprietary organo-mercury seed disinfectants if correctly used control Bunt of wheat, Covered Smut and Leaf Stripe of barley, and Leaf Spot and the Smuts of oats. Sometimes, however, the control of the oat smuts, although good, is not as effective as a formalin treatment.

An interesting feature was recorded in one experiment with the oat smuts, for in a series of weekly sowings with untreated seed it was noted that in the later

sown plots there was a higher percentage of smut than in those sown at earlier dates.

In some circumstances the compounds contained in these organo-mercury seed dressings may cause a characteristic phytocidal effect when they are applied to, and held by the grain in overdoses. The seed may be killed outright or it may begin to germinate and the coleoptile to appear, but further development is abnormal, distinguished by thickening of the tissues of the coleoptile and stunting of the roots. These symptoms are very distinctive, and typical cases are not likely to be confused with injury to seed caused by the incorrect use of copper sulphate, formalin or the hot water treatment. Although instances of injury to seed corn by the organo-mercury seed disinfectants are relatively rare, the main factors responsible for them are known. Weston and Brett[1] found that, provided the grain shows relatively high initial germination, is of sound physical condition and is superficially dry when dusted with these materials, no immediate injury to the grain is likely. Further, if such seed is stored, then, provided it is kept under dry, cool conditions, with adequate ventilation, it is unlikely that any marked decrease in germination will occur during several months. In continuing this investigation it was found that such seed, correctly treated and stored, can be kept for periods up to a year. If, however, it is necessary for a farmer to keep such grain for any lengthy period, he would be well advised to send samples periodically to the Official Seed Testing Station, so that an accurate check could be kept of the germinating capacity. Although the modern seed disinfectants are most effective, research on them continues and one interesting trend is the incorporation with them of plant hormones, as it has been suggested that these 'growth hormones' stimulate root growth and give the plants an earlier start and a better chance. In this country, however, there is little evidence that yields have been materially increased by the use of seed dressings of this type, and research in Canada and the United States indicates that although such plant hormones are potentially capable of inducing physiological activity when applied in dust dressings, they do so in practice only under conditions which occur very rarely.

Field observations over a number of years on the well established English wheat varieties have not shown any very noticeable difference in the intensity of Loose Smut, *Ustilago Tritici*, from year to year; but certain varieties, recently introduced have been more markedly affected. In experimental work with the hot water treatment we find that if the grain has to be stored for any length of time after treatment, and it is not thoroughly dry, then its germinating capacity may be seriously impaired: it is for this reason that after treating our own seed stocks we bring the grain back to its original moisture content by drying over a wind channel. The control measure usually suggested to the farmer is to obtain his seed wheat from a crop known to have been free from this disease, alternatively that he should change to a variety which is less susceptible.

Wheat varieties infected with *Tilletia caries* are usually more susceptible to *Puccinia glumarum*, but loose smutted tillers when examined at harvest time have not shown a similar correlation.

In this country it is usually considered that Leaf Blotch of barley, *Rhynchosporium Secalis*, is of small importance. It is doubtful if this is so for there is no definite evidence of the effect of the disease on yield or quality of grain. In experimental work no indication has been obtained that the disease is seed-borne, and it seems likely that the disease carries over from year to year on rogue barley plants, and on grasses such as *Bromus sterilis*, *B. mollis*, *Dactylis glomerata* and *Hordeum murinum*.

At or just prior to harvest, many enquiries are usually received concerning the cause of thin stands, empty bleached ears, and prematurely ripened grain which are the features of such wheat and barley failures. These partial failures are usually due to the Take-All fungus, *Ophiobolus graminis* and sometimes, in addition, wheat stem sawfly, *Cephus pygmaeus*, or Hessian fly, *Mayetiola destructor*; occasionally species of *Fusarium* are responsible.

[1] Weston, W. A. R. Dillon & Brett, C. C. Seed Disinfection, *Nature*, CXLV, 824.

The major predisposing factor leading to the condition is the taking of corn crops too frequently in the rotation. If a crop of wheat or barley has shown Whiteheads, it should not be followed by either of these crops, and this applies particularly to the farms on the lighter lands. If a corn crop is imperative then oats should be taken, as in East Anglia we have no evidence as yet that this crop is susceptible, although in Wales oats are attacked by *Ophiobolus graminis* var. *Avenae*, a new variety.

The causal factors responsible for 'lodging' of corn crops have always been debatable points; some attribute it to adverse climatic conditions, such as excessive rain, hail or severe winds; others to excess nutrients such as nitrogen, or to abnormal soil conditions: severe mildew attacks have also been suggested as a possible cause, and one form of it, 'Eye-spot Lodging', is attributed to *Cercosporella herpotrichoides*. Ultimately perhaps this trouble will be circumvented by breeding stiffer strawed resistant varieties.

The losses caused by Yellow Rust are not normally serious, although on farms near the East Coast susceptible varieties such as Wilhelmina are often severely attacked. Brown Rust usually develops later in the season and the losses caused by it are seldom severe. Black Rust is rare and when present develops shortly before harvest.

Dr S. P. Wiltshire. The spread of major crop diseases from country to country.

Evidence of the continued spread of major crop diseases was presented in the form of records taken from recent literature. Spread is taking place in spite of existing plant disease legislation and is not confined to any one country but is broadly scattered throughout the world. Instances were given where appropriate action might have been taken to prevent the introduction of a disease into a country had information been available and its import appreciated. Better intelligence is required about the distribution of plant diseases, their methods of transmission, and trade channels. The tentative suggestion was made that quarantine measures of most countries are of sufficient importance to require the organization of a Plant Quarantine Board to deal with them.

Mr F. C. Bawden. Report of sub-committee on plant disease measurement in the field.

Many plant pathologists are dissatisfied with the present vague method of recording diseases in the field. Accordingly a special meeting of the Plant Pathology Committee was held at Rothamsted on 13 February 1941 to consider possible methods of improvement. A Sub-Committee was formed consisting of Messrs F. C. Bawden, W. Buddin, R. W. Marsh, W. C. Moore, with P. H. Gregory *ex officio*, and a scheme for making a disease survey was subsequently drawn up. It was hoped that a start might be made with the tentative proposals in 1941 and an appeal was made for collaborators. For simplicity it was suggested that the survey should be restricted to six diseases: Loose Smut of wheat, potato Virus and Blight, sugar beet Yellows and Downy Mildew, and apple Brown Rot. Instructions for sampling and forms for recording diseases will be supplied on request. It was important that the survey should be as far as possible of fields selected at random, and records from healthy crops were as important as those from diseased ones.

The success of the scheme depends on the willingness of mycologists to co-operate.

Meeting held in the rooms of the Linnean Society of London, Burlington House, Piccadilly, London, W. 1. 20 June 1941

The President, W. C. Moore, Esq., M.A., in the Chair

Dr G. R. Bisby and Dr G. C. Ainsworth. On the numbers of fungi.

(The authors did not supply a summary.)

Miss E. M. Blackwell, Miss G. M. Waterhouse and Miss M. V. Thompson. The invalidity of *Pythiomorpha*.

A detailed study of a strain of '*Pythiomorpha gonapodyides*' sent in pure culture to the Botany Laboratory, Royal Holloway College, led to its recognition as *Phytophthora megasperma*.

An attempt to obtain pure cultures of *Pythiomorpha gonapodyides* from other sources brought nothing other than species of *Pythium* or *Phytophthora*.

An enquiry into the characteristics of *Pythiomorpha* (proliferating sporangia, undulating hyphae, etc.) showed that all of these are characteristics of the Pythiaceae as a whole. An enquiry into the records of *Pythiomorpha gonapodyides* between 1909 and 1936 showed that the descriptions are not always of the same fungus and are of species of either *Pythium* or *Phytophthora*.

It is suggested that *Phytophthora* has not been recorded as an aquatic genus because whenever species of *Phytophthora* are found as water moulds they are named *Pythiomorpha*.

Incidentally a fact of interest and significance to plant pathologists is brought to light, viz. that disease-causing species of *Phytophthora* which infect hosts growing in water-logged soil may for long periods lead a saprophytic existence as water moulds in the same way as disease-causing species of *Pythium* live in soil.

Dr C. T. Ingold. *Tetracladium*-like fungi from a stream in Leicestershire.

A number of *Tetracladium*-like fungi were found growing on decaying alder leaves in the bed of a small stream. They are Hyphomycetes with the branched, septate mycelium developed within the tissues of the leaf, and with conidiophores projecting into the water. The conidia in all species are colourless and produced below water. Nearly all these fungi have a branched spore, usually consisting of four long divergent arms. Four of these fungi with branched spores can definitely be referred to described species, namely, *Tetracladium Marchalianum* De Wild., *Clavariopsis aquatica* De Wild., *Lemonniera aquatica* De Wild. and *Varicosporium Elodeae* Kegel, but six other species appear to be new, and for these new species and genera will have to be erected. All these fungi have been grown in pure culture. In most species colonies on malt agar fail to form spores, but sporulation occurs in from 1 to 2 days when a strip of colony is transferred to water. In the different genera the development of the branched spore is so different, although the final result is so similar, that there seems to be here a striking case of parallel evolution. In some genera the branched spore is a phialospore, but in others it is a thallospore. The possible biological importance of the branched spore was discussed. A few species of Hyphomycetes of the alder-leaf flora do not produce branched spores. This occurs in *Fusarium longissimum* Sacc. & Syd., a species very commonly encountered on the leaves. The spores in this fungus, which clearly does not belong to the genus *Fusarium*, are sigmoid or fusiform thallospores 150–300 μ long.

Dr J. Ramsbottom. Dillenius as a mycologist—and some odd notes.

The fame of John Jacob Dillenius as a mycologist rests primarily on his treatment of fungi in his *Catalogus Plantarum circa Gissam sponte nascentium*, 1719. Recently the Department of Botany, British Museum, acquired a large number of Dillenius's drawings, which included a number labelled 'Fungi Catalogi Gissensis & MSS. de ea referentis'. These comprise most of the species referred to in the Catalogue, and a few additional ones. The drawings were exhibited and comments made on Dillenius's ideas about the origin of fungi, which are essentially those of Marsigli, and Lancisi, 1714; the broad basis of the classification he adopted; his genera *Amanita*, *Boletus*, *Erinaceus*, *Morchella*, *Phallus*, *Fungoides*, *Agaricus*, *Peziza*, *Bovista* and *Tuber*; and on the difficulty he obviously had in realizing the variability of such species as *Armillaria mellea*, and the undue weight he placed on fascicular growth.

The first of the odd notes referred to a statement by Linneus in the account of his Lapland Journey. As is well known, this work was first published in 1811 as a translation by J. E. Smith with the title *Lachesis Lapponica, or a Tour in Lapland.* The remark is in Vol. 1, p. 176, and is of interest as adding to the information about squirrels as mycophagists: 'The Laplanders in this neighbourhood [Westbothnia] had set traps to catch squirrels. Each consists of a piece of wood cloven half way down, and baited with a piece of dried fungus with which the animal is enticed. The fungus used for this purpose is an Agaric with a bulbous stalk and crimson cap (*A. integer* β *Sp. Pl.*).'

Other notes referred to a possible British record of *Amanita caesarea* and to *Agaricus exsuccus* Knapp.

REVIEW

Diseases of British Grasses and Herbage Legumes. By KATHLEEN SAMPSON and J. H. WESTERN. Pp. 85, 8 plates and 15 text-figures. Cambridge University Press, 1941. Paper covers, 5*s*. net.

British plant pathology has always suffered from the lack of a really comprehensive and trustworthy treatise dealing with the various diseases that attack crop and other plants in this country. Perhaps this want may eventually be supplied; meanwhile we are glad to get what we can on the instalment plan, and in recent times we have had some valuable contributions. First, some considerable time ago, came Bewley's *Diseases of Glasshouse Crops*; and, in view of subsequent additions to our knowledge of these, due in large part to the researches carried out at the Cheshunt Experimental Station, it may perhaps be permissible to hint here that a second edition of that useful book would receive a warm welcome. Then came Wormald's *Brown Rot Diseases of Fruit Trees*, and not long afterwards, W. C. Moore's excellent *Diseases of Bulbs*. To these has now to be added Miss Sampson's and Dr Western's account of the diseases of British grasses and herbage legumes.

In his foreword to this book, Professor Sir George Stapledon points out that it is the outcome of some twenty years of research and survey work carried out at the Welsh Plant Breeding Station at Aberystwyth, with which the senior author has been associated from the very beginning, Dr Western having joined in it at a later date. It is clear therefore that the authors are fully competent for their task. As they point out in their introduction, the importance of the subject becomes more apparent when it is realized that 'grass' or 'herbage' is not a unit, but consists of a collection of species and strains which have often widely different propensities. Breeders of new types, and propagators of clonal races of improved strains, have therefore frequently to contend with diseases, which, to others, may seem of little importance. The golf-green keeper, that upsetter of the natural ecological equilibrium of 'turf', is another worker whose efforts are often impaired by outbreaks of disease. The farmer himself may suffer seriously from a disease such as Clover Rot. Finally, the plant pathologist is bound to benefit from the additional knowledge concerning some of the more or less uncommon diseases which he may from time to time be called upon to diagnose and treat. There is ample justification therefore for the publication of a work of this kind.

In the section of the book devoted to grasses, the diseases—practically all due to parasitic fungi—are classified under the captions: Smuts, Bunts, Rusts, Mildew, Leaf Spots and Inflorescence Diseases. A note on the systemic infection of species of *Lolium* by fungi of unknown relationships follows. The diseases of seedling and established turf are then dealt with, and the section ends with a brief reference to Fairy Rings. One might demur to the inclusion of Grass Choke (*Epichloe typhina*) amongst the inflorescence diseases, alongside of Ergot (*Claviceps*), although of course the inflorescence sometimes is the seat of the stromata of the systemic fungus, and seed transmission has been established with certainty in *Festuca rubra*. Further, *Sclerotium rhizodes* is a parasite of upland hay rather than of turf; but separate captions for these two diseases would perhaps be hardly worth while, and they are not serious misfits where they stand.

The diseases of herbage legumes (mainly clovers) are dealt with under the headings: Root and Crown Diseases, Miscellaneous Root Diseases, Stem Diseases, Leaf-Spot Diseases, Mildews and Rusts. The flower disease—Anther Mould, due

to *Botrytis anthophila*—is described and the probability of the occurrence of Virus diseases of red clover in Britain is pointed out. Virescence of the carpels in both white and red clover, resulting in failure to produce seed, is alluded to under the heading Diseases of Unknown Origin. Lastly, instances are given of diseases due to mineral deficiency, some of which have become of serious importance in recent years.

The symptoms of the various diseases are described clearly and succinctly, and useful information concerning the causative parasites is supplied. Where control measures are known and are practicable they are briefly mentioned. A very valuable feature is the generous sprinkling of references to previous literature, the authors and titles being assembled in a list more than twelve pages long, at the end of the book. The eight plates contain thirty-five good half-tone photographic reproductions of many of the diseases described, or of mycological details of the parasites, the latter being supplemented by the fifteen text-figures. There is a good index in which the names of the hosts and parasites are printed in heavy type, thus standing out clearly from the other entries.

Altogether, though more in the nature of a bulletin than a substantial book, this account of the diseases of our native herbage plants forms a valuable addition to British phytopathological literature; moreover, its price, especially under present difficult conditions, is a modest one, an incentive rather than a deterrent to the possession of the book.

G. H. Pethybridge

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